November 2009

The Region of the Thorax

even the innominate artery, may be drawn upward above the margin of the manubrium sterni, in consequence of the comparatively greater laxity of the connective tissue. The upper portion of the thymus gland is also often in the way. In the adult, however, unless there is an unusual origin for the innominate artery, it can hardly be made to mount so high as the supra-sternal notch by stretching the neck, as already stated (page 222). In operating below the isthmus the inferior thyroid veins should never be forgotten, and the knife should be introduced with the back toward the sternum, to avoid the thymus gland and other structures in that situation.

THE REGION OF THE THORAX.

The landmarks of this region are so obscured by the superficial and external structures that they are not easily recognized without particular knowledge of the component parts in their several localities. They are of the greatest importance, on account of their medical application in the physical examination of the chest as relates to diagnosis by auscultation or percussion in affections of the thoracic organs. Attention will therefore be first drawn to the general construction of the thorax, and then to its principal features in detail, before considering its topographical relations.

The skeleton of the thorax (Plate 28) is composed of the dorsal vertebræ, the ribs and costal cartilages, and the sternum, so arranged as to form a conical, movable framework, which gives attachment to the muscles of respiration, and affords protection to the heart and the lungs. The method of the articulation of the ribs with the dorsal vertebræ behind, and with the sternum through their cartilages in front, is one of the most ingenious pieces of mechanism in nature, which not only permits the unceasing momentary alterations in capacity of the thoracic cavity during respiration, but also fulfils the function of support and protection.

The *ribs* are twelve pairs of flattened, bony hoops, which are attached to the spinal column between the neck and the loins, and so arranged that they project anteriorly and describe a series of arches which increase in length to the seventh and in obliquity to the ninth from above downward. The obliquity of the ribs is so great that the sternal end of any rib is on a level with the vertebral end considerably below it in numerical order. Thus, the first rib in front corresponds to the fourth rib behind, the fifth to the ninth, the seventh to the eleventh. The seven upper ribs have separate cartilaginous prolongations which connect them with the sternum, and are distinguished as *true* or *sternal* ribs, whereas the lower five are called *false* or *asternal* ribs, because they are not joined directly with the sternum. Of the latter, the eighth, ninth, and tenth ribs have cartilaginous prolongations which unite and turn upward to join the cartilage of the seventh rib so that they are brought indirectly in connection with the sternum. The eleventh and twelfth ribs are without cartilages and terminate in free ends in the muscular walls of the abdomen, and hence are called *floating* ribs. Very rarely the eighth rib presents the anomaly of having an independent cartilaginous prolongation to the sternum (Plate 29), and therefore would then come within the classification of a true rib. Each rib is peculiarly modified in conformation to its position in the series, and from the first to the last they are so remarkably adapted that the slight rotation which can take place only at their vertebral articulations occasions not only a slight elevation of their sternal ends, but an eversion of their lateral surfaces, so that by their united action the thoracic cavity is enlarged in every direction. The vertebral extremities or *heads* of the intermediate ribs, which closely resemble one another in all respects, are covered with articular cartilage, which in all but the first and last three is divided by a slight transverse ridge into two facets for articulation with the bodies of two contiguous vertebræ. The lower facet is the larger, and is received upon the vertebral body which corresponds numerically with the rib.

The *costo-vertebral joints* are each provided with a capsular ligament, including two synovial membranes separated by a *fibro-cartilaginous inter-articular ligament*, which extends from the intervertebral disk to the transverse ridge between the facets on the head of the rib. These joints are reinforced anteriorly by fibres which radiate from the anterior border of the head of each rib to the side of the body of the vertebra above, to the front of the intervertebral disk, and to the front of the body of the vertebra below, forming the *stellate ligament.* The narrowed portion beyond the head of each rib is called the *neck*. This is smooth in front, but roughened behind for the attachment of the *posterior accessory ligament*, consisting mostly of transverse fibres which connect it with the front of the transverse process of the corresponding vertebra. The neck is generally two and a half centimetres, or about an inch, in length, and ends in a roughened process called the *tuberosity*, which presents on its inner surface a smooth oval facet for articulation with the end of the transverse process of the vertebra. This is also provided with a delicate capsular ligament and encloses a synovial membrane.

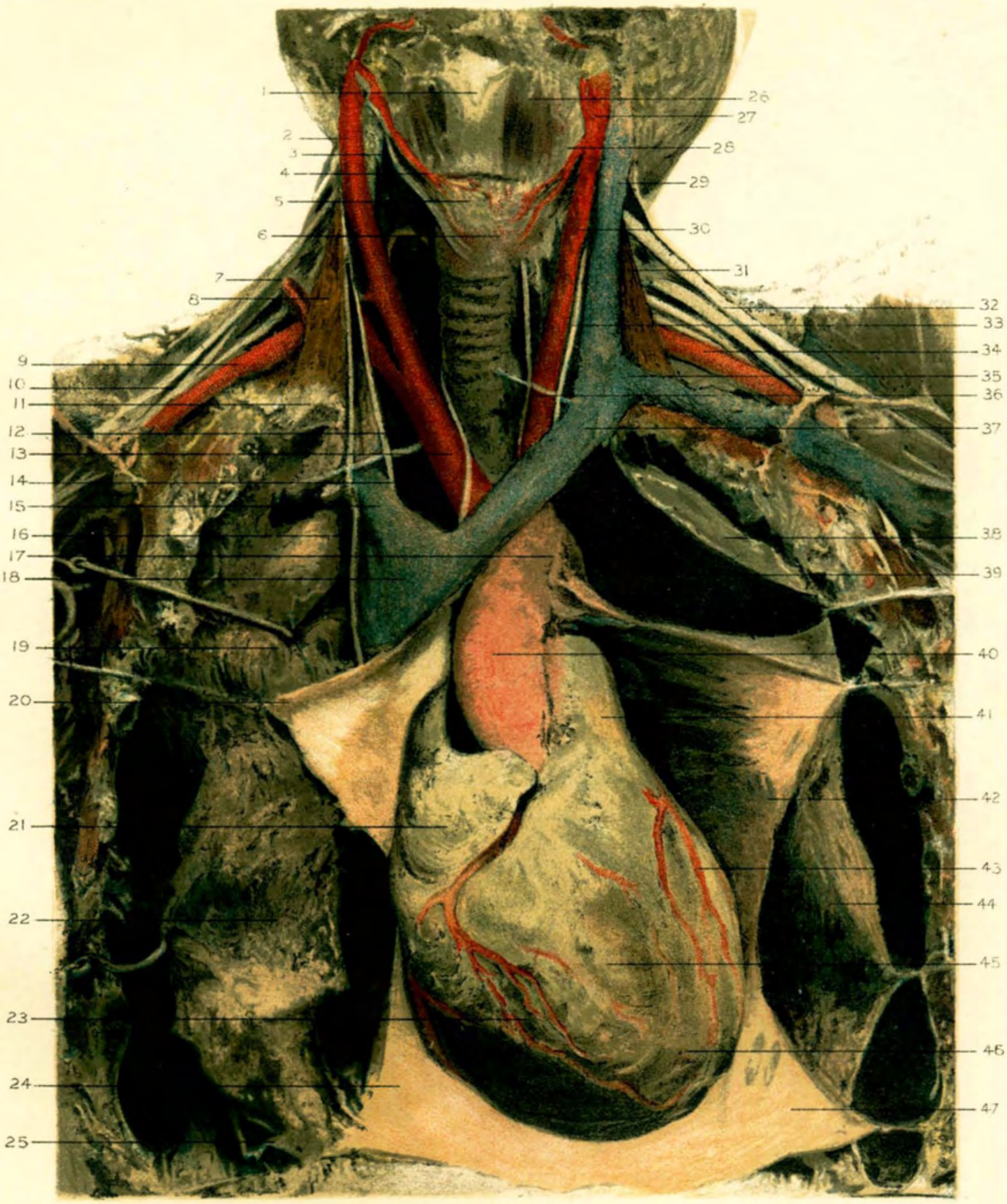
The fibres which connect the necks and tubercles to the transverse processes are called, from their relative positions, *anterior*, *middle*, and *posterior costo-transverse ligaments*. The *anterior* consists of a broad band of fibres extending between the upper border of each rib to the lower border of the transverse process above. It is in relation in front with the intercostal vessels and nerves. The *middle* consists of short fibres which pass from the back part of the neck of each rib to the anterior surface of the adjacent transverse process. The *posterior* consists of a short, strong band which passes obliquely from the top of the transverse process to the neck of the rib just back of the tubercle. Between the last two ribs and the transverse processes of the corresponding vertebræ the middle and posterior costo-transverse ligaments are very loose and allow considerable freedom of motion to these ribs. It should be noted in this connection that the transverse processes of the dorsal vertebræ become more oblique from above downward, and consequently the obliquity of the neck of each rib increases. Beyond the tuberosity each rib is prolonged forward as a narrow, flattened, bony hoop, constituting the *body* or *shaft*. The inner surface is concave and smooth, and the outer surface is rough. The upper border is rounded and thick, and gives attachment to the internal intercostal muscles. The lower border is grooved for the accommodation of the intercostal vessels and nerve, and presents a sharp external edge for the attachment of the external intercostal muscle. The body of each rib from the second to the tenth at a short distance from its neck suddenly bends forward and changes the direction of its curve. At this point of divergence there is upon the external surface an oblique ridge called the *angle*, which upon each successive rib downward is situated farther outward, and corresponds to the insertion of the slips of the sacro-lumbalis muscle. Furthermore, as each rib approaches its sternal end there is a tendency for the body to twist in its axis, so that the posterior surface behind the angle is inclined downward and inward, while toward the middle of the body the bone is inclined downward and outward. This gives the spiral shape which can best be appreciated when an isolated specimen is placed upon a flat surface, it being then found that both ends cannot be kept down at the same time. In consequence of the obliquity and curvature of the ribs, a pistol-ball upon striking one of them may be deflected in its course, and if it has entered in front may be found in the muscles of the back, or if it has entered from behind may pass out near the sternum. The sternal portions of the ribs are broader, thicker, and more porous than elsewhere, and have cupped depressions in their ends to receive the costal cartilages.

The ribs which have noteworthy individual peculiarities are the two upper and three lower ribs upon each side. The *first* rib is broad, nearly flat, and very curved, but without any twist in its axis. It has a small rounded head, which has only *one* articular facet for articulation with the body of the first dorsal vertebra. The neck is long and slender and ends in a decided tuberosity. In very pronounced specimens the upper surface presents two shallow oblique impressions in front of the middle of the body, which are separated by a slight ridge. The posterior impression is for the subclavian artery, the anterior part of the ridge for the attachment of the scalenus anticus muscle (page 220), and the anterior impression for the subclavian vein. Between the tuberosity and the impression for the subclavian artery there is a rough surface for the scalenus medius muscle. The *second* rib is not so broad as the first, and conforms more to the succeeding ribs below, but it is without any twist and is also flatter. The head is provided with two facets for articulation with the bodies of the first and second dorsal vertebræ. About the middle of the body there is a roughness for the attachment of the scalenus posticus and serratus magnus muscles. On both the first and the second rib the angle is very slightly developed. The *tenth* rib is long and curved, and has only a single facet on its head.

PLATE 35.

Preparation to show the relations of the heart and the great vessels at the root of the neck. The pericardium is opened and held aside.

1. The thyroid notch.
2. The right common carotid artery.
3. The right superior laryngeal nerve.
4. The right superior thyroid artery.
5. The crico-thyroid membrane, with the crico-thyroid artery.
6. The cricoid cartilage.
7. The right supra-scapular artery.
8. The right scalenus anticus muscle.
9. The right subclavian artery.
10. The right brachial plexus of nerves.
11. The right first rib.
12. The right pneumogastric nerve.
13. The innominate artery.
14. The right recurrent laryngeal nerve.
15. The right innominate vein.
16. The right phrenic nerve.
17. The transverse arch of the aorta.
18. The superior vena cava.
19. The upper lobe of the right lung, drawn outward.
20. The pericardium drawn outward to expose the root of the heart.
21. The right auricle of the heart.
22. The middle lobe of the right lung.
23. The right coronary artery of the heart.
24. The pericardium opened and resting upon the diaphragm.
25. The lower lobe of the right lung.
26. The left thyro-hyoid muscle.
27. The left superior thyroid artery.
28. The left superior laryngeal nerve.
29. The left internal jugular vein.
30. The left common carotid artery.
31. The left scalenus anticus muscle.
32. The left brachial plexus of nerves.
33. The left pneumogastric nerve.
34. The left subclavian artery.
35. The left subclavian vein.
36. The left recurrent laryngeal nerve.
37. The left innominate vein.
38. The upper lobe of the left lung, drawn aside.
39. The descending portion of the arch of the aorta.
40. The ascending portion of the aorta.
41. The pulmonary artery.
42. The upper portion of the pericardium, drawn aside to show the root of the heart.
43. The left coronary artery of the heart.
44. The lower lobe of the left lung, drawn aside.
45. The right ventricle of the heart.
46. The apex of the heart.
47. The lower portion of the pericardium, drawn aside to show the apex of the heart.



Dissected, Photographed and Colored from Nature by GEORGE MC CLELLAN, M.D.

Armstrong & Co. Lith Boston.

The *eleventh* and *twelfth* ribs are less well developed in every respect than the others, and have each a single facet on the head, but are without neck or tubercle and terminate in sharp-pointed extremities. The difference between them is that the eleventh has a slight angle and groove on its under border, while the twelfth has neither. Occasionally there is found a rudimental thirteenth rib on one or both sides in either the cervical or the lumbar region. The sixth, seventh, and eighth ribs are those most frequently fractured, on account of their being usually more exposed than the others.

The cartilaginous prolongations of the ribs, or *costal cartilages*, which bring them in connection with the sternum, resemble in shape the sternal ends of the bony ribs, into which they are fitted without articulation, being merely adjusted and enveloped in a thick perichondrium. In length they increase downward to the seventh, and thence gradually decrease. The first costal cartilage corresponds in breadth to its proper rib, and, like the second, third, and fourth costal cartilages, which are narrower, is continued to the sternum in the line of its rib. The cartilages of the lower true ribs, also narrow, converge upward to be joined to the sternum; the seventh is the largest, and receives the cartilage of the eighth rib at its under surface, as the eighth does that of the ninth and the ninth that of the tenth. The cartilages of the floating ribs are merely tips to the bones. The union of the several cartilages with the sternum offers all the characteristics of a joint, with special differences in some instances.

The *first chondro-sternal joint* is a synchondrosis, the cartilage being continued into a depression on the outer angle of the top of the manubrium sterni, which admits of very little motion. This cartilage is often partially or completely ossified at middle life. The *second chondro-sternal joint* occurs at the junction of the manubrium with the gladiolus of the sternum, and consequently there are double articular surfaces, with an interarticular fibro-cartilage and a synovial membrane. This joint is of topographical value, as it can be located through the superficial structures by its relation to the constant ridge between the manubrium and gladiolus sterni (Plate 28). The succeeding costal cartilages are joined to the margins of the sternum in a manner very closely resembling the attachment of the head of the first rib to the body of its vertebra. The *seventh chondro-sternal joint* often resembles the first, and has slight motion. Each of these joints is provided with a capsule from the adjoining periosteum, which is strengthened by the *anterior chondro-sternal ligament*, composed of fibres radiating from the ends of the costal cartilages on the front of the sternum, where they interlace with one another above and below and from the opposite side and with the tendinous attachments of the pectoral muscles. The *posterior chondro-sternal ligament* is the corresponding fibrous interlacement on the endothoracic surface of the articulations. The cartilages of the eighth, ninth, and tenth ribs are connected to one another and to the cartilage of the seventh rib by the *interchondral ligaments*. The costal cartilages are very elastic in youth, those of the lower ribs particularly so. In certain diseased conditions these cartilages become ossified and are liable to fracture.

The *sternum*, or breast bone, consists in the adult of three light, flat, spongy bones which are supported by the costal cartilages in the front of the chest, and taken together form a narrow, long, bony mass shaped somewhat like an old Roman sword. The upper portion resembles the handle, and is called the *manubrium* (or *presternum*), the central blade-like portion is the *gladiolus* (or *mesosternum*), and the lower pointed process (usually cartilaginous) is the *ensiform process* (or *metasternum*), which, because of its variability of form and frequently forked termination, is also known as the *xiphoid appendix*. The manubrium is the broadest and thickest part, and presents on each lateral border *three* articular surfaces, the upper of which is the largest, for the articulation with the clavicle (page 324), the middle just below it for the cartilage of the first rib, and the lower *half* facet for the upper border of the cartilage of the second rib. The upper border of the manubrium is on a level with the lower border of the second dorsal vertebra, is smooth, and is noticeable through the skin between the two sterno-clavicular joints as a marked depression, called the *supra-sternal notch*.

The *gladiolus* is ordinarily broadest between the articulations of the cartilages of the fifth ribs. Upon the lateral borders are the articular notches for the rib cartilages, and running across the bone between them from side to side are imperfectly-marked ridges, indicating the original segmentation in its formation. The *ensiform cartilage* is irregular, notched or bifid, and is often bent forward or to one side owing to some habitual occupation during life, as the pressure exerted by a cobbler's last. There is a *chondro-xiphoid ligament* which extends from the cartilage of the eighth rib on each side to this process.

The chief difference in the length of the sternum in the female (seventeen and a half centimetres, or about seven inches) and in the male (twenty centimetres, or about eight inches) is in the gladiolus, which in the former (Plate 41, Fig. 1) is shorter and broader proportionately than in the latter (Plates 28 and 29). The outer surface of the sternum is slightly convex, the inner concave. Looked at from the side, the anterior surfaces of the different portions will be seen to occupy different planes, so that there is always a slight bend at the junction of the manubrium and gladiolus. The plane of the manubrium inclines forward, that of the gladiolus less so, and the ensiform cartilage is usually vertical, although, as just stated, it is subject to variations. The outer layer of compact tissue which encases the spongy substance of the sternum affords very slight protection, but the periosteal covering is very dense, and thicker than usual in other bones. The joint between the manubrium and gladiolus is rarely ossified, and there is often a decided yielding or tendency to sinking backward of the top of the gladiolus, which has in some instances been erroneously surmised to be the result of fracture. As stated, the *ridge* in this situation is constant, and of the greatest service in counting the ribs, for, as it corresponds to the attachment of the cartilage of the second rib on each side (page 245), it is easy to ascertain any other by counting downward. The median line of the sternum is not continuous with the median line of the abdomen, but inclines rather to the right.

The *intercostal spaces* in relation to the sternum are noticeably wider above and narrower below. The *second intercostal space* is generally the widest (Plate 29), but they all vary with the expansion and contraction of the chest in respiration. They can be increased by bending the body over to the opposite side.

The skeleton of the thorax, considered as a whole, is somewhat flattened in front and behind, so that its width from side to side exceeds its depth, which is characteristic of the human thorax as compared with that of quadrupeds, and makes the supine position naturally an easy one to man. The *anterior surface* is slightly convex, corresponding to the direction of the sternum and the costal cartilages by which it is formed. The *lateral surfaces* are convex, and formed by the arching bodies of the ribs and the intercostal spaces. The *posterior surface* is also convex from above downward, and is formed by the dorsal vertebræ and the portions of the ribs posterior to their angles. The thorax increases in dimension from the first rib to the eighth, where its transverse diameter is greatest. There is much variability in the form of the thorax at all periods of life, and very commonly there is a want of symmetry in the two sides, the circumference of the right usually being greater than that of the left. In early childhood the thorax is relatively smaller than in the adult, the ribs are flatter and less hooped, and up to the end of the third year breathing is more *abdominal* than thoracic, while after that age, in boys, and in men too, it is effected by the action of the muscles attached to the lower seven ribs as well as the diaphragm. In adult females the upper portion of the thorax is less compressed from before backward, and the upper ribs are naturally brought more into play, even when not influenced by artificial pressure, so that in them breathing is *thoracic*. A horizontal section made through the middle of the thorax (Plate 41, Fig. 2) presents a cordiform or heart-shaped outline, owing to the projection of the bodies of the dorsal portion of the vertebral column into the back of the thoracic cavity. Such a section will also show that the ribs are cut *obliquely*. In the male a section made on a level with the lower borders of the third ribs anteriorly and through the body of the eighth dorsal vertebra posteriorly will generally cut the eighth, seventh, sixth, fifth, and fourth ribs (Plate 41, Fig. 2).

The *dorsal vertebræ*, or, more properly, *thoracic vertebræ*, are peculiarly adapted with facets and demi-facets for the articulation of the ribs. The *first* corresponds in general conformation to the vertebra prominens of the neck, and the *last* to the first vertebra of the lumbar region. Their bodies are thicker behind than in front, as are also the dorsal intervertebral disks, so that when they are articulated they present a natural curvature with the convexity backward. The dorsal spines are very oblique, and it should be remembered that their tips do not correspond to the bodies. That of the first is opposite the disk between the first and second bodies; that of the second is opposite the body of the third; that of the fourth is on a level with the disk between the fifth and sixth; those of the fifth, sixth, seventh, and eighth are opposite the seventh, eighth, ninth, and tenth. That of the ninth corresponds to the body of the tenth, the tenth to the eleventh, and the eleventh is opposite the disk between the eleventh and twelfth. The further description of the dorsal vertebræ will be found under the anatomy of the back, in Vol. II.

The terms superior and inferior apertures of the thorax are misleading, such openings existing only in the skeleton. The superior, corresponding to the *summit* of the thorax, gives passage to the structures at the root of the neck and to the dense fibro-cellular tissue which is prolonged over them from the deep cervical fascia into the thoracic cavity. The inferior opening, or *base*, is closed in the recent state by the diaphragm, which forms a muscular partition between the chest and the abdomen. Although the diaphragm is arched upward to a considerable extent and its muscular portions fall and rise continually in unison with the efforts at respiration, thereby alternately increasing and diminishing the capacity of the thorax, the actual space occupied by the lungs and heart is very limited compared to that indicated by the outward appearance of the bony cage. The diaphragm (page 320) is on a level with the junction of the fifth costal cartilage and rib on the right ride, and of the sixth on the left (Plate 27), corresponding to the height to which the liver reaches. It is attached in front to the ensiform cartilage, but it curves downward to become attached to the last rib on both sides.

The *skin* over the anterior surface of the thorax is delicate and closely connected with the superficial fascia. It is tense and very slightly movable over the sternum, but at the sides, in consequence of the traction exerted by the underlying muscles, the pectoralis major and minor and the latissimus dorsi, forming the folds of the axilla, it is freely movable. The skin over the sternum in dark-hued males is usually the seat of the growth of curly black hairs associated with large sebaceous glands. The superficial fascia is generally loose, and does not contain much fat except in relation to the mammæ, where the fascia subdivides into two layers which surround these glands and send numerous septa between their various lobes. The *ligamenta suspensoria* are fibrous processes which project from the anterior layer to the skin around the nipples.

The mammary glands in the female (Plate 44, Fig. 1) extend from the third to the sixth rib on each side between the axillæ and the sternum. They vary in size and shape according to their functional development and the general physical condition of the individual. When fully formed, with the enveloping skin, fascia, and fat, they appear as globular prominences, the *breasts,* from which protrude conical, brownish-pink-colored eminences, the *nipples,* which are surrounded at their bases by a zone of colored skin, the *areola.* The nipple is usually situated opposite the fourth intercostal space, and twelve centimetres, or about four and a half inches, from the middle line; but its position is variable and cannot be relied upon as a reference for definite measurement (Plate 27). The skin of the areola is extremely thin, and is covered with a number of little whitish tubercles which contain the orifices of sebaceous glands. The skin of the nipple is provided with sensitive papillæ, and consists of retiform tissue interspersed with unstriped muscular fibres. It is highly vascular. The milk-ducts open upon the summit of the nipple by from fifteen to twenty orifices. The *mammary gland* is a racemose glandular structure, consisting of from fifteen to twenty lobes, which are supported by the septa inflected from the anterior layer of the fascial investment. The lobes are quite independent of one another, so that in mammary abscess it is often necessary to make several openings, and they should be made in a straight direction radiating from the nipple, in order to avoid as far as possible injuring the milk-ducts.

The *arteries* which enter the margins of the gland are small and numerous, and they do not accompany the ducts. Those for the upper lobes are derived from the thoracico-acromial artery, those for the outer lobes from the long thoracic and external mammary arteries, and those for the inner lobes from the anterior intercostal arteries (Plate 44, Fig. 1). The deep *veins* accompany the arteries; the superficial veins form an anastomosing circle around the base of the nipple and end in the superior thoracic veins.

The *lymphatic vessels* are numerous, and chiefly converge toward the axillary glands, following the outer border of the great pectoral muscle (Plate 44, Fig. 2), while others terminate in the anterior mediastinal glands in relation to the internal mammary vessels (Plate 41, Fig. 1), penetrating the thoracic walls through the upper three intercostal spaces. The distinction between the sub-sternal and axillary glands with reference to their possible involvement in cancer should be clearly understood. The former receive the lymphatic vessels from the inner portion of the breast, so that in cases where they have become implicated they are anatomical obstacles to the effectual removal of a scirrhous breast, notwithstanding the most thorough enucleation of the axillary glands with the tumor. The superficial lymphatics from the vicinity of the nipple pass to a gland below the outer border of the clavicle.

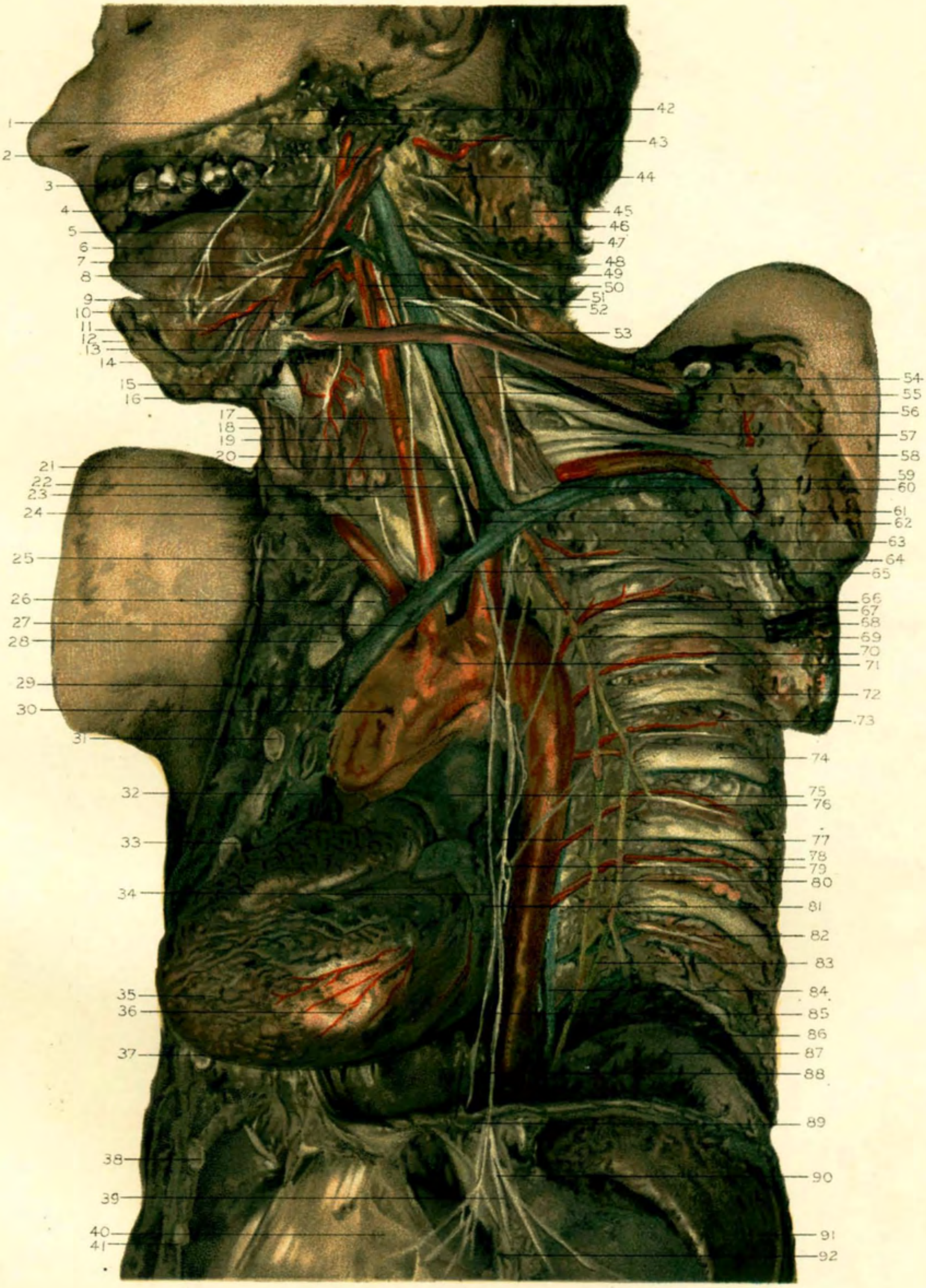
The *nerves* are chiefly derived from the anterior and lateral cutaneous branches of the intercostal nerves. The superficial fascia along the border of the sternum is pierced by the anterior cutaneous branches of the intercostal nerves, which emerge with the anterior intercostal branches of the internal mammary artery, the second, third, fourth, and fifth being distributed to the mammary gland. The connections of the intercostal nerves explain the diffusion of pain complained of in many affections of the breast. In the female there is always a loose layer of connective tissue underneath the gland, and often a bursa, which allows it to glide freely over the pectoral muscle, to which it is in no way attached in the healthy state. In the male the gland is rudimental, and, as the substratum of connective tissue is less loose, it follows to a greater extent the movements of the pectoralis major muscle. Occasionally the male mammæ are developed, and in rare instances have been known to secrete milk; and there are numerous recorded cases of supernumerary mammæ in the female, variously situated in the back, axilla, groin, and thigh. In the female the various modifications which the breasts assume after puberty are coincident with the other phenomena attendant upon pregnancy.

In the *operation for removal of the breast* the arm of the affected side

PLATE 36.

Dissection of the pneumogastric nerve on the left side, and its relations to the phrenic and sympathetic nerves. (From a female, aged thirty-seven years.)

1. The parotid gland.
2. The digastric muscle.
3. The styloid process.
4. The stylo-glossus muscle.
5. The lingual (or gustatory) nerve.
6. The hypoglossal nerve.
7. The glosso-pharyngeal nerve.
8. The lingual artery.
9. The digastric muscle attached to the hyoid bone by the loop of deep fascia.
10. The great cornu of the hyoid bone.
11. The attachment of the omo-hyoid muscle to the hyoid bone.
12. Section through the symphysis of the lower jawbone.
13. The superior laryngeal nerve.
14. The crico-thyroid muscle.
15. The superior thyroid artery.
16. The top of the thyroid cartilage.
17. The descendens hypoglossi nerve.
18. The right sterno-thyroid and hyoid muscles.
19. The thyroid body.
20. The internal jugular vein.
21. The pneumogastric nerve.
22. The lower cervical ganglion of the sympathetic nerve.
23. The common carotid artery.
24. The recurrent laryngeal nerve.
25. The innominate artery.
26. The sternal end of the right clavicle.
27. The left innominate vein.
28. The left first rib.
29. The anterior margin of the right lung.
30. The ascending portion of the arch of the aorta.
31. The right second rib.
32. The right auricle.
33. The right third rib.
34. The left phrenic nerve.
35. The apex of the left ventricle of the heart.
36. The branches of the posterior coronary artery.
37. The right fifth rib.
38. The right sixth rib.
39. The gastric branches of the left pneumogastric nerve.
40. The diaphragm over the liver.
41. The right seventh rib.
42. The sawn end of the ramus of the lower jawbone.
43. The occipital artery.
44. The spinal accessory nerve.
45. The trapezius muscle.
46. The internal jugular vein.
47. The second cervical spinal nerve.
48. The third cervical spinal nerve.
49. The upper—long—cervical ganglion of the sympathetic nerve.
50. The external carotid artery.
51. The internal carotid artery.
52. The descendens hypoglossi nerve.
53. The omo-hyoid muscle.
54. The scalenus anticus muscle.
55. The sympathetic nerve.
56. The left phrenic nerve.
57. The cords of the brachial plexus of nerves.
58. The subclavian artery.
59. The subclavian vein.
60. The insertion of the scalenus anticus muscle at the inner border and upper surface (tubercle?) of the first rib.
61. The pneumogastric nerve.
62. The œsophagus (distended).
63. The first intercostal artery coming from the subclavian artery.
64. The internal mammary artery.
65. The left innominate vein.
66. The second intercostal artery and nerve.
67. The origin of the subclavian artery.
68. The left third rib.
69. The sympathetic nerve.
70. The left third intercostal artery and nerve.
71. The transverse portion of the arch of the aorta.
72. The left fourth rib.
73. The left fourth intercostal artery and nerve.
74. The left fifth rib.
75. The pulmonary artery.
76. The left fifth intercostal artery and nerve.
77. The roots of the pulmonary vessels and bronchi.
78. The sixth intercostal artery and nerve.
79. The œsophageal branches of the pneumogastric nerve.
80. The great splanchnic nerve.
81. The left auricle of the heart.
82. The seventh intercostal artery and nerve.
83. The lesser splanchnic nerve.
84. The azygos minor vein.
85. The pneumogastric nerve.
86. The left eighth rib.
87. The diaphragm arching over the spleen.
88. The phrenic nerve.
89. The gastric branches of the pneumogastric nerve passing through the diaphragm to the stomach.
90. The terminal branches of the pneumogastric nerve.
91. The spleen.
92. The stomach.



Dissected, Photographed and Colored from Nature by George Mc Clellan, M. D.

Armstrong & Co. Lith. Boston.

should be drawn upward and backward, so as to put the great pectoral muscle on the stretch, and a bevelled incision should be made, first on one side and then on the other, around the base of the gland, in a direction toward the axilla. The *entire* gland, including the nipple, should always be extirpated, to avoid as far as possible a recurrence of the morbid state, and if the axillary glands are involved, as they generally are in cancer, the incision can be extended so as to expose them. They will be found surrounding the deep vessels (Plate 45), and often adherent to the axillary vein and its tributaries, so that their removal is very difficult and hazardous, whereas the excision of the gland alone is comparatively a simple and easy task. Upon complete removal of the gland, its base will be found to conform with the slight bulge of the subjacent pectoralis major muscle, which with its sheath of deep fascia will be seen usually untouched at the bottom of the wound.

The deep fascia of the anterior surface of the thorax is exposed after removal of the double layer of the superficial fascia and the contained mammary gland. It serves as a thin aponeurotic sheath for the great pectoral muscle, into which it sends prolongations between its component fasciculi. This fascia is attached to the front of the sternum and to the clavicle. It is very delicate over the upper part of the pectoralis major; but, as it is reflected from the outer border of that muscle across the axillary space to the latissimus dorsi muscle, it becomes considerably thicker. It is continued under the latter muscle to the spinous processes of the dorsal vertebræ. Below the deep thoracic fascia is quite strong and blends with the sheaths of the recti muscles.

The *pectoralis major muscle* (Plate 16, and Plate 44, Fig. 1) is the large, triangular, fleshy mass situated at the side of the chest, consisting of two special portions, the fibres of which converge toward the shoulder. The *clavicular portion* arises chiefly by fleshy fibres from the front of the inner half of the clavicle and the capsule of the sterno-clavicular joint, and extends obliquely outward, when the arm is at the side of the body, to the insertion of the deltoid muscle, with which it blends on the surface of the shaft of the humerus, and also gives off an expansion to the brachial fascia. In relation to the deltoid muscle above, the clavicular portion is separated only by a *furrow* which lodges the cephalic vein and the humero-thoracic artery. When this furrow is marked, the coracoid process can be felt through it and may be a useful landmark (page 330). The *sternal portion* is peculiar in the manner both of origin and insertion of its fibres, which are arranged in two layers which are often quite distinct from each other, being separated by a cellular interval. The superficial layer arises by tendinous fibres from the front of the sternum interlacing with those from the opposite muscle, and usually by a slip from the sheath of the rectus abdominis muscle. The deeper layer arises by fleshy fibres from the cartilages of the five or six upper true ribs, the slip from the first costal cartilage being sometimes absent. The fibres of these two layers are directed in a radiating manner toward their insertion, being disposed in such a manner that the fibres of the deeper layer pass obliquely upward under the fibres of the superficial layer, so that their relative positions are reversed, the lower becoming the upper, as they terminate in a flat tendon at the *outer margin* of the bicipital groove under the insertion of the clavicular portion. The attachment of the sternal portion gives off a delicate expansion which covers the bicipital groove and is connected with the capsular ligament of the shoulder-joint. The twist in the sternal portion produces the anterior rounded border of the axilla, and covers the axillary vessels and nerves at the upper part of that space.

The pectoralis major muscle is remarkable for its tendency to separate into radial lamellæ, commonly offering accessory slips which pass to the humerus or the brachial fascia. Its function is chiefly to draw the arm forward and rotate it inward upon the chest. When the arm is raised it can draw it downward, or, if the fixed point is above, the muscle can assist in raising the trunk, and also serve as an auxiliary muscle of inspiration. The arteries to this muscle come from the long and short thoracic branches of the axillary artery. The nerves are derived from the anterior thoracic branches of the subjacent brachial plexus. The *cleft* between the clavicular and sternal portions of the pectoralis major muscle, when the arm is extended outward, is often clearly indicated by a depression in the skin, and, as it corresponds to the course of the commencement of the axillary artery, that vessel may be sought for here and a ligature applied with considerable ease (page 343).

The pectoralis major muscle must be removed in order to expose the pectoralis minor and subclavius muscles. The former will be found separated from the sternal portion of the pectoralis major by a quantity of loose cellular tissue, and the latter beneath the clavicular portion, enclosed in the strong costo-coracoid membrane. The *pectoralis minor muscle* (Plate 44, Fig. 2) is a triangular fleshy mass composed of fibres which arise by flattened tendinous slips from the sternal ends of the third, fourth, and fifth ribs, and from the aponeurotic expansion over the subjacent intercostal muscles. Besides these there are often accessory slips of origin, either above or below. It ascends to be inserted by a narrow, flat tendon into the upper and inner edge of the coracoid process of the scapula, and gives a fibrous extension to the coracoid attachments of the coraco-brachialis and biceps muscles. The insertion of the pectoralis minor passes across the middle of the axillary vessels and nerves (page 339). Between the pectoralis minor and major muscles there are branches of the thoracico-acromial artery and the anterior internal thoracic nerve. The long thoracic artery runs along the axillary border of the pectoralis minor. The function of this muscle is to depress the shoulder, by drawing the scapula forward and downward.

The *costo-coracoid membrane* consists of several leaflets of fascia of varying density, extending from the cartilage of the first rib to the coracoid process. Above it is attached to the outer and inner edges of the *subclavian impression* on the under surface of the clavicle, and thus completely encloses the subclavius muscle. The outward and more superficial expansion is thin, and splits so as to pass over and under the coracoid attachment of the pectoralis minor muscle, to be continued with the axillary fascia, forming the *anterior part* of the sheath of the axillary vessels. This leaflet is pierced by the cephalic vein, the thoracico-acromial artery and vein, the anterior thoracic nerves, and the superior thoracic artery. The deeper portion of this membrane is called the *costo-coracoid ligament,* because of its strong fibrous character. It arches over the axillary vessels and nerves as they pass over the first rib.

The *subclavius muscle* is a round mass of fibres which arises by a strong tendon from the junction of the first rib and its cartilage, and is inserted into the subclavian impression of the clavicle as far as the coraco-clavicular ligament. It receives filaments from the lower cervical nerves, and its function is to fix and depress the clavicle.

When the above muscles are completely removed from the anterior surface of the thorax there is a strong glistening aponeurotic layer of fascia spread over the intercostal spaces, which serves to bind down the fibres of the intercostal muscles and to afford additional protection to the spaces. The intercostal muscles consist of two separate layers, external and internal, the short fleshy fibres of which cross one another. There are eleven pairs of each set of intercostal muscles, and they are arranged peculiarly as they approach the vertebral and sternal ends of the ribs.

The *external intercostal muscles* commence at the tubercles of the ribs, pass obliquely from the outer border of the rib above to the top of the rib below, throughout the series, and extend as far forward as the costal cartilages, where the muscular fibres disappear and are replaced by strong, oblique, tendinous fibres, which constitute a membranous expansion, to the border of the sternum. The *internal intercostal muscles* commence at the sternum and pass obliquely in the opposite direction to the external muscles from the inner edge of the groove above and from the costal cartilage to the upper border of the rib below, as far backward as the angles of the ribs, where they are reinforced by additional fibres, the *subcostal muscles*, which extend upward and downward, passing over one or two ribs between their attachments. The direction of the fibres of the external intercostals corresponds to the external oblique muscle of the abdomen, and that of the internal intercostals is similar to the internal oblique. The internal intercostals are thicker and their muscular fibres more pronounced anteriorly (Plate 40) than they are posteriorly. The intercostal muscles are exercised chiefly in the movements of the ribs in ordinary breathing. When the first and second ribs are fixed by the scalene muscles the action of the external intercostals raises the anterior part of the ribs and everts their lower borders, thus enlarging the thoracic cavity, as in inspiration. The special action of the internal intercostals is not definitely understood, but they probably depress the ribs, as in expiration. In the spaces between the costal cartilages the two sets of fibres, it is supposed, assist each other in inspiration. The internal surface of the intercostal spaces is covered with a thin adherent fascial expansion similar to that upon the outer side of the chest wall. It is closely connected with the outer layer of the pleura.

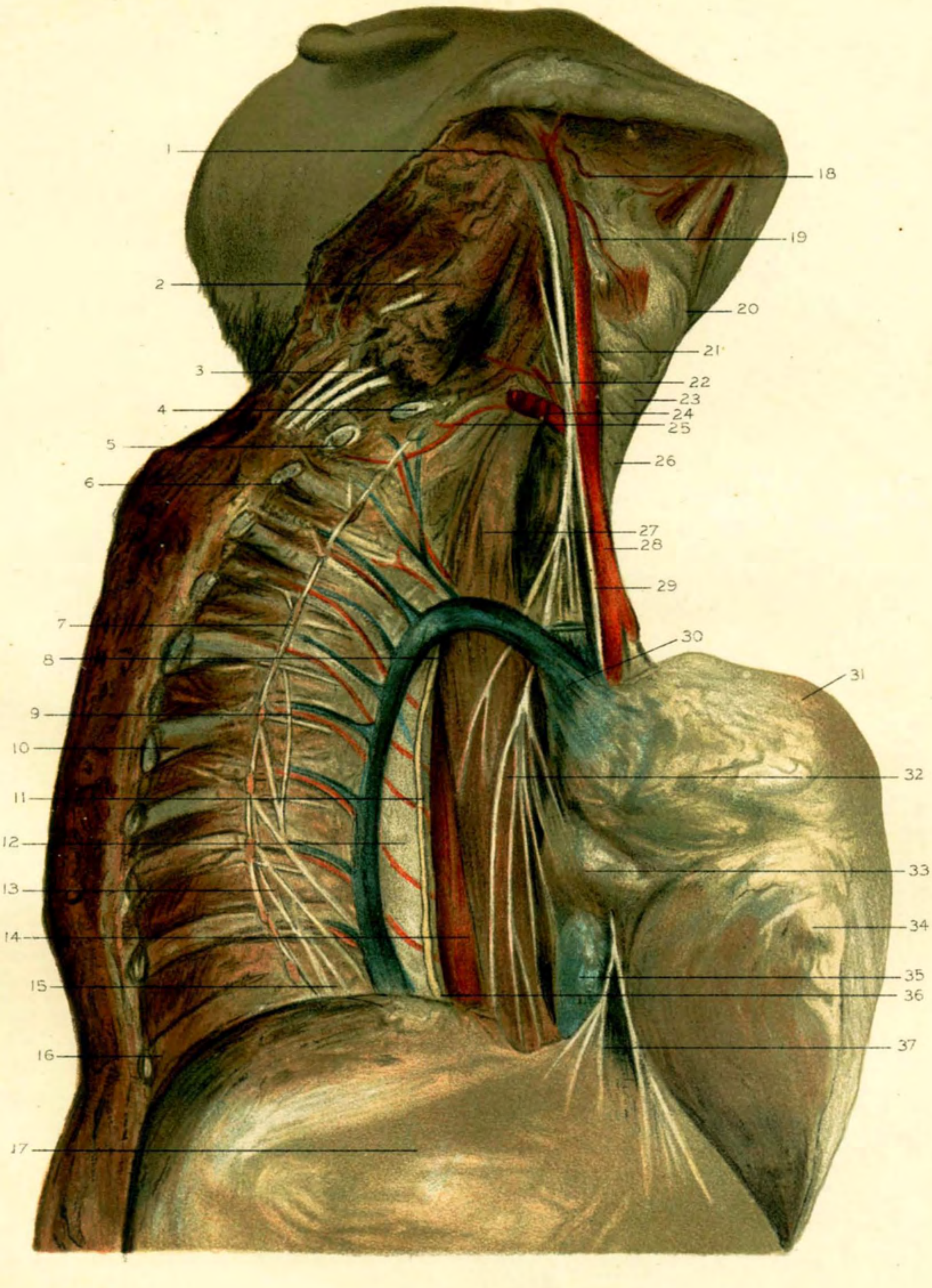
Within the thorax, on the under surface of the sternum and cartilages of the lower true ribs, there is a thin, flat muscle, of variable development, called the *triangularis sterni.* It arises from the ensiform cartilage and the sides of the lower part of the gladiolus and the adjacent cartilages, and ascends obliquely outward, to be inserted, by fleshy slips, into the cartilages of the lower true ribs, generally from the sixth to the third. The fibres of the lowest slip pass transversely outward, and are in reality continuous with the anterior portion of the transversalis abdominis muscle. The action of the triangularis sterni muscle is to depress the costal cartilages in expiration. Its nerves are derived from the intercostal nerves, and its arteries are branches of the internal mammary on both sides, which are situated between it and the costal cartilages.

The *internal mammary artery* on either side is given off from the first portion of the subclavian artery, opposite the origin of the thyroid axis at the inner border of the scalenus anticus muscle, and descends into the thorax behind the clavicle and the first rib, in close relation to the phrenic nerve, which passes over it from without inward to descend behind the artery (Plates 39 and 40) between the pleura and the pericardium. The internal mammary artery with a vein on each side of it runs parallel with the border of the sternum, and twelve millimetres, or about half an inch, from it (Plate 41, Figs. 1 and 2), on the surface of the pleura, until it reaches the fifth or sixth intercartilaginous space, where it passes between the cartilages and the triangularis sterni muscle. This artery can be easily ligated within the second intercostal space through an incision directly over its course. In relation to the seventh costal cartilage it divides into its terminal branches, the *musculo-phrenic,* which supplies twigs to the diaphragm and the lower intercostal muscles, and the *superior epigastric,* which enters the abdominal wall between the sheath of the rectus

PLATE 37.

The posterior mediastinum, exposed on the right side by removing the ribs near their angles and drawing forward the heart and lungs, to demonstrate the entrance of the vena azygos major into the superior vena cava, and the distribution of the right pneumogastric and phrenic nerves.

1. The right occipital artery.
2. Section of the sterno-mastoid muscle.
3. The cut brachial plexus of nerves.
4. Section of the first rib.
5. Section of the second rib.
6. Section of the third rib.
7. The chain of ganglia of the sympathetic nerve.
8. The thoracic duct, crossing behind the œsophagus and aorta to the left side.
9. The intercostal vessels and nerve in relation to the seventh rib.
10. The seventh rib.
11. The thoracic duct.
12. The vertebral column, covered with the thoracic fascia.
13. The greater splanchnic nerve.
14. The descending thoracic aorta.
15. The lesser splanchnic nerve.
16. Section of the eleventh rib.
17. The hepatic arch of the diaphragm.
18. The lingual artery.
19. The descending thyroid artery, and superior laryngeal nerve.
20. The notch in the thyroid cartilage.
21. The common carotid artery.
22. The thyroid axis.
23. The cricoid cartilage.
24. The right subclavian artery.
25. The first intercostal artery.
26. The trachea.
27. The œsophagus.
28. The innominate artery.
29. The right phrenic nerve.
30. The vena azygos major vein, entering into the superior vena cava.
31. The heart, within the pericardium, drawn forward.
32. The œsophageal plexus of nerves, from the pneumogastric nerve.
33. The right auricle of the heart, within the pericardium.
34. The right lung, drawn outward.
35. The inferior vena cava, emptying into the right auricle of the heart.
36. The thoracic duct, coming through the aortic opening in the diaphragm.
37. The branches of the right phrenic nerve on the diaphragm.



Dissected, Photographed and Colored from Nature by George Mc Clellan, M.D.

Armstrong & Co. Lith. Boston.

abdominis muscle and the extra-peritoneal fascia and anastomoses with the deep epigastric. In its course it distributes a branch which accompanies the phrenic nerve, the *arteria comes nervi phrenici,* branches to the structures within the anterior mediastinum, branches which pass to the five or six upper intercostal spaces and inosculate with the aortic intercostal arteries, and perforating arteries which pass through the intercostal spaces and supply the pectoralis major muscle, the mammary gland (page 250), and the skin over the chest. At the first rib there is a lateral infracostal branch from the internal mammary, which in intra-thoracic growths sometimes becomes greatly enlarged. The two *internal mammary veins* are usually of unequal size, and are provided with a number of valves. Behind the first intercostal muscle the veins unite and empty on the left side into the innominate vein, and on the right, generally, into the superior vena cava. In close proximity to the internal mammary vessels there are from six to eight *lymphatic glands,* which receive the lymphatic vessels from the upper part of the rectus abdominis muscle, the diaphragm, the intercostal spaces, and the inner portion of the mammary gland (page 251). They empty into the right lymphatic duct and left thoracic duct respectively.

If the sternum and costal cartilages are carefully removed, the anterior wall of the thorax will be opened so as to display the prolongation of the deep cervical fascia downward and the anterior surfaces of the right and left pleural sacs. In the middle line there is a tubular expansion of fascia extending between the pleuræ all the way from the neck to the ensiform cartilage of the sternum, and on each side the fascia becomes thickened and is attached to the pericardium, forming the *sterno-pericardial ligaments.* The sub-sternal tubular sheath can generally be demonstrated by inflation with a blow-pipe, and may allow pus to travel from the root of the neck and point below the ensiform cartilage in the upper part of the abdominal wall. Upon slitting up this layer of fascia the subdivision of the interpleural space, called the *anterior mediastinum,* is exposed (Plate 26, Fig. 1). This is a shallow space included between the anterior portions of the pleuræ, the pericardium, and the sub-sternal fascia just described, especially that portion of it which corresponds to the gladiolus. Its direction is usually not vertical, as it inclines to the left side because of the position of the heart, over the root of which, opposite the origin of the great vessels, it is also narrowest, owing to the approximation of the pleuræ. As the left pleura recedes from the middle line, this space is wider below than it is above. Within the anterior mediastinum there are the sub-sternal lymphatic glands, embedded in a variable amount of fatty tissue, and on the left side the internal mammary vessels for a part of their course (Plate 41). The space does not properly enclose the attachments of the triangularis sterni, sterno-hyoid, and sterno-thyroid muscles, as they are covered by reflections of the endothoracic fascia continuous with the deep cervical fascia. The so-called *superior* mediastinum is that portion of the inter-pleural space which extends from the manubrium in front to the upper dorsal vertebræ behind and above the pericardium. It contains, besides the great vessels and contiguous portions of the trachea and œsophagus, the *thymus gland* in the infant or its remains in the adult. It is not truly separated from the anterior mediastinum except when the expansion of the lungs in full inspiration brings their pleural envelopes into contact.

The thymus gland is a soft, grayish-red-colored, lobulated body, of variable size and shape, situated behind the manubrium sterni and overlapping the great vessels of the heart covered with the pericardium (Plate 26, Fig. 3, No. 6). At birth it is five centimetres, or about two inches, in length, wider below than above, and it continues to grow until the end of the second year, often ascending into the root of the neck, and sometimes reaching the lower border of the thyroid body. From the second year to the sixth it does not undergo much change, but after the latter age it gradually atrophies, and at puberty there is very little trace of its original glandular structure left, a fatty mass taking its place and rarely projecting above the sternum. It bears much resemblance to the racemose glands, but its function is unknown. It seems to be the great functional lymphatic gland of early life, each lobe consisting of lobules composed of clusters of lymph-follicles surrounded with vascular connective tissue and numerous lymph-cells. The branches from the internal mammary arteries furnish it with most of its blood.

The pleuræ (Plate 26, Fig. 1, Nos. 6 and 16) are the serous membranes surrounding the lungs, and are so arranged as to form two distinct completely closed sacs, each having a *parietal layer*, or *pleura costalis*, which is in contact with the thoracic wall, and a *visceral layer*, or *pleura pulmonis*, which is reflected over the contained lung. The enclosed space between the two layers of each pleura is called the *cavity of the pleura*, the surfaces of which are smooth and moist, but it is not ordinarily of appreciable dimensions. It is now regarded as a large lymph-space, like that of the peritoneum, and communicates by stomata with the surrounding subpleural lymphatic vessels. During life, when healthy, the two layers glide freely upon each other, and thereby facilitate the movements of the lungs. The costal pleura is the thickest, and is connected especially to the inner surfaces of the ribs by a well-marked connective tissue, which allows of its being easily detached. The pulmonary pleura is very delicate and transparent, and is also attached to the lung tissue by elastic connective tissue, which serves as a nidus for a plexus of capillaries from the bronchial arteries, and a plexus of lymphatic vessels which communicate with the lymph-spaces in the areolar tissue of the lobules of the lung. Inflammation of the pleura may produce a thickening and roughening of its lateral surfaces, so that in the expansion of the lung a *friction* sound is produced. This is peculiarly modified if the inflammation results in a distention of the pleural sac by serum (hydrothorax), or by pus (empyema), or by air (pneumothorax). When the cavity of the pleura requires tapping (paracentesis thoracis) to evacuate it of an accumulation of fluid, the sixth or seventh intercostal space, midway between the sternum and the spine, is generally selected, and the trocar should always be introduced at the middle of the space, during inspiration, to avoid the intercostal vessels and nerves. On the right side the fifth intercostal space should be selected, in order to avoid the diaphragm (Plate 27). The right and left pleural cavities are distinct, and their respective membranes are reflected posteriorly from the roots of each lung, in connection with a fold of the prevertebral fascia, to the diaphragm below, having a free curved edge between the diaphragm and the lung. This is called the *ligamentum pulmonale*. As the apices of the lungs extend upward into the root of the neck behind the attachments of the scalenæ antici muscles on the first ribs, their pleuræ naturally are similarly expanded. On the right side the pleura usually reaches a little higher than on the left. In this position it bears an important relation to the subclavian artery in its first portion. At the root of the neck the endothoracic fascia is expanded somewhat in the shape of a dome, to which the deep cervical fascia is usually attached. Sometimes there is a prolongation of this fascia, which brings the dome into relation with the transverse process of the seventh or sixth cervical vertebra, and a few muscular fibres have been found in it, probably segmented from the scalenus posticus muscle. The parietal layer of the pleura over the apex of each lung is intimately connected with this dome-like expansion of the fascia. The presence of this *extra*-pleural fascia at the root of the neck, with its possible modifications consequent upon any inflammatory infiltration, is worthy of the consideration of the physician, who may be confused by the adventitious sounds produced by it upon auscultation, in the same manner as the surgeon finds it often difficult to distinguish between true and false crepitus in injuries about the joints. The extent and limitation of the reflections of the pleuræ upon the inner wall of the thorax are very difficult to understand without actual demonstration. Below they practically follow the attachments of the diaphragm, which, except about its margin and at its central tendon, is covered by the pleuræ. In front the right pleura holds a position more nearly the middle line, being opposite the junction of the seventh rib and its cartilage, while the left is placed at a variable distance away from it and a little lower, in consequence of the interposition of the heart. Posteriorly both pleuræ descend as far as the head of the last rib, and laterally the right pleura is in relation to the lower border of the *ninth* rib, and the left pleura to the lower border of the *tenth* rib. In consequence of this disposition of the pleuræ over the diaphragm it often happens that a pistol-ball which has penetrated the thoracic wall will roll down over the diaphragm to the lowest part of the back of the pleural cavity.

The pulmonary layers of the pleura upon each side are not coextensive with the costal layers, except during forced inspiration. Therefore there are portions of the folds of the pleuræ where their surfaces ordinarily are in contact. These are called the *pleural sinuses,* and they are found along the costal origins of the diaphragm, between the pericardium and the sternum, and between the pericardium and the diaphragm (Plate 26, Fig. 1, No. 8). Upon the anterior margins of the last two sinuses there are folds which blend with the tissue of the pericardium, and through which the phrenic nerves on their way to the diaphragm can be seen in front of the roots of the lungs. If a transverse section of the thorax is made, it will be noticed that the pleuræ do not come into contact, and that there is a distinct space between them extending from before backward (Plate 41, Fig. 2). This is called the *interpleural space*, and is subdivided into the anterior, middle, and posterior mediastina. Of these the middle is the largest compartment, and contains the heart within the pericardium, the vessels which pass to and from the base of the heart, the phrenic nerves, and the bifurcation of the trachea and the bronchial lymphatic glands. The anterior mediastinum is in front of the pericardium, and, as it is first exposed upon opening the thorax anteriorly, it has already been described (page 259), as being in the natural order of approaching the study of this region. The *posterior mediastinum* is behind the pericardium, between it and the dorsal vertebræ, from the fourth to the twelfth, and contains the descending thoracic aorta, the œsophagus, the pneumogastric nerves, the venæ azygos major and minor, the thoracic duct, and lymphatic glands (Plate 38).

The lungs are two large spongy organs within the pleuræ, occupying during life the whole of the cavity of the thorax on each side of the mediastinum, and separated from each other by the heart enclosed in the pericardium. They vary even in health from a pale-pinkish color to a mottled gray, depending upon their vascularity and inflation. With age they generally become darker and spots are visible upon their surface, probably due to the deposition of particles of carbonaceous matter which have been inhaled. After death they usually appear of a dark-purple hue, especially at the back, in consequence of venous stagnation. When the lungs are fully distended, as in forced inspiration (Plate 30), they will be seen to conform to the shape and limitation of their respective pleura. Each lung has a rounded *apex*, which extends into the root of the neck (Plate 27) two and a half centimetres, or about an inch, within the pleural domes (page 262), and a concave *base,* which conforms to the arch of the diaphragm upon which it rests. They fit into the pleural sinuses when fully expanded, and reach downward posteriorly as far as the eleventh rib on each side,—the right lung in the axillary line being in relation to the ninth rib, and the left lung to the tenth rib.

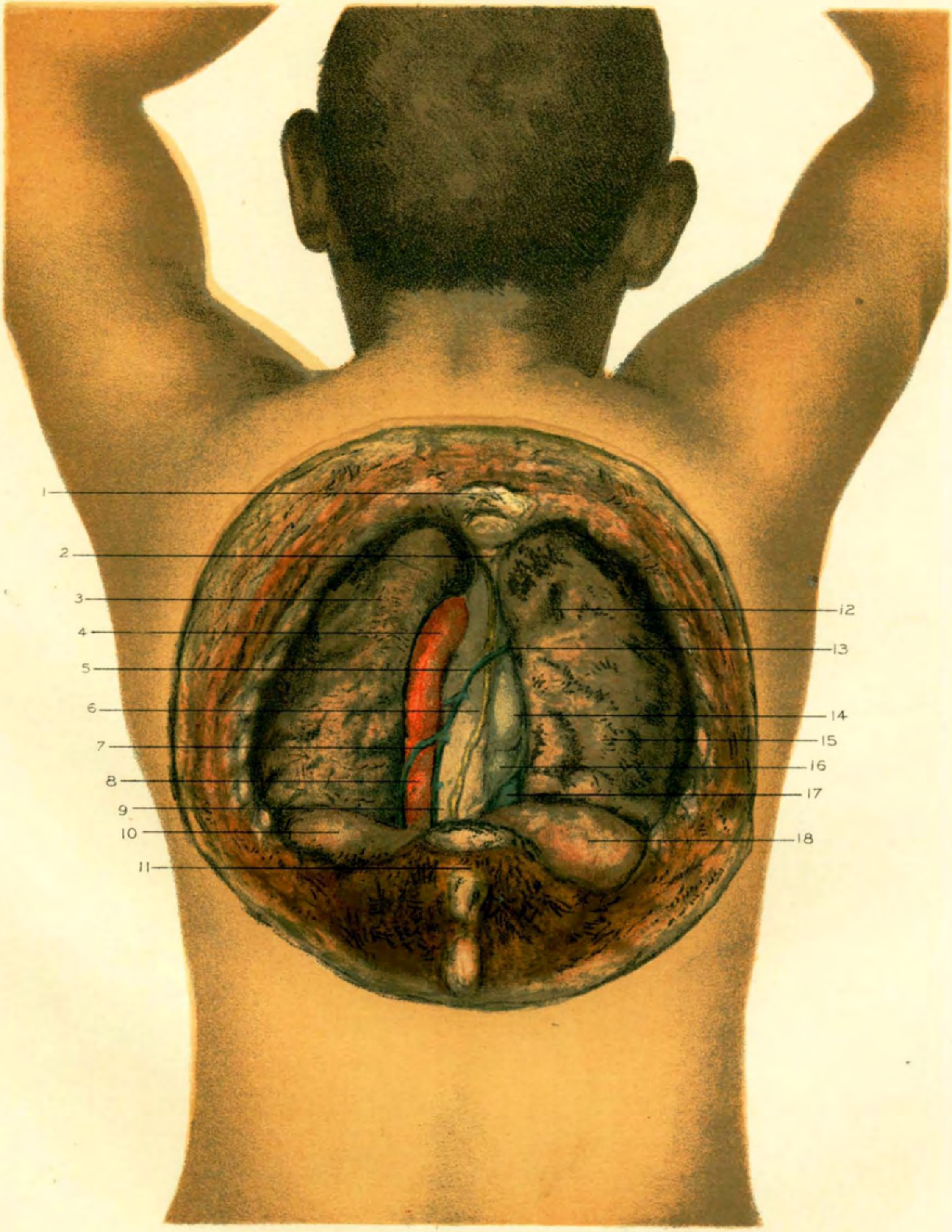
The right lung is thicker and shorter than the left, the concavity of its base being also higher, as it corresponds to the arch of the diaphragm over the liver. It is often notched on its mediastinal surface, presenting depressions foı the superior and inferior venæ cavæ. The left lung is excavated on its mediastinal surface for the reception of the heart, and its apex has an impression for the left subclavian artery. The apex of the left lung does not mount quite so high above the clavicle as does that of the right. The anterior edges of both lungs present characteristic differences. That of the right lung is nearly straight or vertical, and that of the left is oval or oblique. The extent to which they approach each other depends upon the degree of their expansion. In forced inspiration, when the lungs are absolutely healthy, the anterior edges of the lungs *meet* over the root of the heart and the origin of the great vessels within the pericardium (Plate 30). The surfaces of the pleuræ are thus brought into contact to the extent of several inches, between the lower border of the manubrium sterni and the junction of the cartilages of the fourth ribs with the sternum. At such times the anterior edge of the right lung is absolutely vertical and parallel with the median line of the chest, and the area of the heart which is uncovered by the left lung is limited to the lower third of the right ventricle. In ordinary tranquil breathing the anterior edges of the lungs do not come together (Plates 31 and 32). In a state of collapse both lungs shrink back into their recesses within the thoracic cavity (Plate 33).

From careful observations made upon both the living and the dead body at different ages, it would seem to the author that only when healthy do the lungs meet in front over the root of the heart upon a prolonged and full inspiration. There is generally some interspace between them in the anterior mediastinum. The right lung comes forward more readily than does the left, even in moderate inspiration, so that the anterior edge of the right lung approaches more nearly the middle line. The lower portion of the right lung also expands more readily below in relation to the diaphragm than does the lower portion of the left lung, whereas the converse appears to be true with regard to their apices. Not only does the left lung not come forward so readily, but its lower portion does so only upon prolonged inspiration, and thereby reaches the anterior limit of its pleural sac. When both lungs are normal and fully inflated in the well-developed adult male, in the erect position, the lower front edge of the right lung corresponds approximately to the oblique line of the interspace between the cartilages of the sixth and seventh ribs (Plate 27), while the lower front edge of the left lung is in relation to the lower border of the seventh rib, and extends but a little way beyond the sternal end of that rib (Plate 30). These limitations will be lessened by the breadth of a rib if the individual be placed in the recumbent position, and in the female or poorly-nourished youth they may be lessened still more, so that the anterior lower edges of the right and left lungs may reach respectively the lower borders of the fifth and sixth ribs, corresponding to the height which the arches of the diaphragm normally reach and hold relatively (page 322) to each other. It should be therefore understood that in respiration the upper portions and posterior surfaces of the lungs are at all times in close contiguity with their pleural sacs, and that the anterior medial and lower edges retire and advance according to the effort of expiration or inspiration and the healthy condition of the pleuræ which allows their natural freedom of motion. It is very doubtful if the anterior lower edges of the lungs ever do completely fill their proper portions of the pleural cavities, and an adhesion existing anywhere between the lung and its sac will influence the degree of motion of the lung. In forced expiration the lower edges of the lungs posteriorly do not ascend higher than the lower borders of the *seventh* ribs. A transverse section made across the root of the neck from the first dorsal vertebra to the top of the sternum (Plate 14, Fig. 1) will show that the apex of the right lung is larger than that of the left, and that they are both in this locality of oval form. A transverse section across the thorax from the eighth dorsal vertebra to the lower borders of the third ribs (Plate 41, Fig. 2)

PLATE 38.

The posterior mediastinum and its contents, as seen on removal of the dorsal vertebræ (from the second to the ninth) with portions of their contiguous ribs. The lungs are expanded so as to show their proper relations posteriorly.

1. The body of the first dorsal vertebra.
2. The thoracic duct, winding across the œsophagus to enter the superior mediastinum.
3. The upper portion of the left lung.
4. The descending portion of the arch of the aorta, overlapped above by the left lung.
5. The vena azygos major, crossing to the right of the œsophagus.
6. The œsophagus, distended.
7. The vena azygos minor.
8. The thoracic aorta.
9. The thoracic duct, after its entrance into the thorax from the aortic opening.
10. The upper surface of the left arch of the diaphragm.
11. The spine of the ninth dorsal vertebra.
12. The upper portion of the right lung.
13. The vena azygos major entering the superior vena cava.
14. The left auricle of the heart.
15. The lower portion of the right lung.
16. The base of the left ventricle of the heart.
17. The inferior vena cava.
18. The upper surface of the right arch of the diaphragm.



Dissected, Photographed and Colored from Nature by George Mc. Clellan, M.D.

Armstrong & Co. Lith. Boston.

shows that both lungs are here somewhat palm-shaped, with their bases toward the spine and their narrower portions toward the sternum.

Each lung is divided into an *upper* and a *lower lobe* by a *great fissure* which commences behind about seven and one-half centimetres, or three inches, from the apex, opposite the fourth dorsal vertebra on the right and the third on the left, and descends obliquely forward to the junction of the seventh rib with its cartilage on the right, and opposite the sternal end of the sixth rib on the left. There are, however, many alterations in the relative positions of the fissures, and their terminations cannot be foretold. There is generally a deep notch in the anterior edge of the left lung over the pericardium where it is in relation to the apex of the heart (Plate 30, No. 42), and occasionally the right lung is similarly notched about the cartilage of the fourth rib (Plate 29). The right lung is subdivided by a secondary fissure which commences about opposite the sixth rib, near its angle, and extends usually to the cartilage of the fourth rib and thus marks off a *middle lobe*. The lower primary lobes of both lungs are the largest, and they chiefly constitute the posterior portions, whereas the anterior portions are mainly formed by the upper lobes. Occasionally the left lobe has a semblance of a secondary fissure, and occasionally also the secondary fissure in the right lung is undeveloped.

The convex outer surfaces of the lungs are free and moulded to the interior of the thoracic walls, and the concave inner or mediastinal surfaces are connected to the heart and the trachea by the bronchial tubes, with their vessels, nerves, and lymphatics, and by the pulmonary arteries and the pulmonary veins. These structures collectively form the *roots of the lungs*, and are held together by areolar tissue, and supported below by reflections of the pleuræ, called the *ligamenta lata pulmonalia*. The roots of the lungs are attached to the bottom of a deep cleft, the *hilum pulmonale*, which is situated a little nearer the posterior than the anterior surfaces and above the middle of each lung. If the thorax be opened from behind by removing the dorsal vertebræ and contiguous portions of their ribs (Plate 39), it will be seen that the vena azygos major arches over the root of the right lung and the aorta over the root of the left lung. Behind the right root are the posterior pulmonary plexus of the pneumogastric nerve and the vena azygos (Plate 37), and behind the left are the descending aorta and the posterior pulmonary plexus of the pneumogastric nerve (Plate 36). In front of each root are the anterior pulmonary branch of the pneumogastric and the phrenic nerve. In front of the root of the right lung is also the superior vena cava (Plate 33).

The *trachea* at the root of the neck, as previously described (page 236), passes deeply from the outer surface in front of the œsophagus to its bifurcation into the right and left bronchi within the superior mediastinum. The bifurcation is about on a level with the body of the fourth dorsal vertebra posteriorly, and opposite the second intercostal space anteriorly. Within the chest the trachea is crossed by the arch of the aorta, the deep cardiac nerves passing between them. The œsophagus projects a little to the left of the middle line at the root of the neck, and is closely connected by areolar tissue to the trachea, which is placed between the upper portions of the two pleuræ. The recurrent laryngeal nerves from the pneumogastric nerves ascend on each side of the neck in the grooves between the trachea and the œsophagus (Plate 39).

The bronchi vary in length, direction, and diameter. The *right bronchus* is about two and a half centimetres, or an inch, in length, and, passing nearly horizontally, enters the right lung about opposite the body of the fifth dorsal vertebra. Its diameter is greater than that of the left bronchus, and, as the ridge of separation between the two bronchi at the bottom of the tracheal tube inclines to the left of the middle line, foreign bodies which may chance to fall down the trachea are more likely to pass into the right bronchus. The *left bronchus* is about five centimetres, or two inches, in length, and descends obliquely to enter the left lung opposite the sixth dorsal vertebra. The left bronchus passes in front of the œsophagus and thoracic duct and under the arch of the aorta (Plate 38). In structure the bronchi resemble the trachea (page 236), the right having from six to eight rings and the left from nine to twelve. At the roots of the lungs the bronchi subdivide into two branches, the *bronchial tubes*, corresponding to the primary lobes of the lungs. The lower branch of the right bronchus sends off a small branch to the third lobe on that side. The right bronchus at the root of the right lung is behind the right pulmonary artery, and the left bronchus also holds the same relative position, being behind the corresponding pulmonary artery. On both sides the pulmonary veins are in front of the arteries (Plate 41, Fig. 1). Within the lungs the bronchial tubes divide dichotomously into posterior and anterior branches, which again subdivide into lateral branches, and these diverge in all directions throughout the organs until their termination in the *lobules*, where they are known as *bronchioles*. There is no communication between the bronchioles, so that if any obstruction occurs in one branch the air cannot reach the vesicles to which it naturally leads.

The pulmonary and bronchial vessels, the lymphatics and nerves, all accompany the ramifications of the bronchial tubes, and are united to them by connective tissue, the arteries always being behind and the veins in front of the tubes. Within the *structure of the lungs* the tubes cease to have regular cartilaginous rings, circular muscular fibres with patches of cartilage here and there constituting the walls of the branches. They are lined throughout with the mucous membrane continued from the trachea, which is covered with columnar ciliated epithelium. Gradually all traces of cartilage disappear and the walls present irregular dilatations, which commence in pouches surrounding the ultimate tubules. These enlarge in diameter and end as sacculated passages, the *infundibula*, whose walls consist of blind pouches, the *alveoli* or *air-vesicles*. They are surrounded and connected everywhere with an *elastic tissue*, in which there are only slight traces of muscular tissue, and which is derived from the peculiar elastic sub-serous tissue closely investing the surfaces of the lungs beneath the pleura. Upon this elastic tissue the remarkable expansibility of the lungs depends. When the chest is opened the lungs collapse to about a third of their ordinary bulk (Plate 33), in consequence of their elasticity. This elastic tissue is prolonged from the surfaces into the inner structure of the organs, forming numerous angular spaces of various sizes about the alveoli, and called the *pulmonary lobules*. When the lungs are distended, the surface is everywhere marked by polygonal areas, which vary in size at different ages. These areas are mapped out into smaller ones, which are less distinct. They indicate the lobules, which are larger on the surface than in the interior of the lung. After air has once entered into the lobules it cannot be entirely pressed out, owing to their spongy texture, and any portion of the lung will therefore float on water, but it will sink immediately if inspiration has not taken place, and owing to this property such a demonstration is frequently made use of as a test in medico-legal investigations. It should be remembered that a portion of lung-tissue from which the air has been dispelled by pneumonic exudation will also sink in water. When pressed between the fingers, the escape of air from the lung-tissue produces crepitation. When the air-vesicles are ruptured, the air escapes into the interlobular tissue, producing *pulmonary emphysema*, and if there is infiltration of serum into this tissue it is called *œdema of the lung*. If the lung-tissue is torn, a reddish frothy liquid is exuded, consisting of mucus, air, and blood commingled.

The terminal branches of the pulmonary artery form nets of capillary vessels which accompany the bronchioles in their distribution to the alveoli, where they are covered by epithelium on both surfaces and project into the air-vesicles. The *pulmonary capillaries* are very crowded in relation to the air-vesicles, and the plexus surrounding one air-vesicle is arranged in a single layer and has no communication with that of another vesicle. There are only the delicate wall of the vesicle and the walls of the capillary vessels between the blood and the air, so that the purification of the blood takes place through the absorption of the oxygen and the elimination of carbonic acid and watery vapors. The blood circulating through the capillary plexuses is returned by the *pulmonary veins*, which are very minute at first, but gradually coalesce so that they form branches of increasing calibre and size, which freely anastomose, and, following somewhat the course of the arteries, eventually terminate at the root of each lung in two main trunks which convey the oxygenated blood to the left auricle of the heart. There are no valves in any of the pulmonary veins. Besides the pulmonary system of vessels there are the nutrient vessels of the lungs, derived from the small bronchial arteries. On the right side there is usually one bronchial artery, which arises either from the first aortic intercostal or from the aorta in common with the left bronchial artery. On the left side there are usually two bronchial arteries, both arising from the aorta. They enter at the roots of the lungs posterior to the bronchi, and are distributed to the walls of the tubules, the larger pulmonary vessels and the pulmonary lymphatic glands, and the inflections of the elastic interlobular tissue.

The bronchial veins mostly empty on the right side into the vena azygos major, and on the left into the superior intercostal vein, although some of them empty their blood into the corresponding pulmonary veins.

The *pulmonary lymphatic vessels* are very numerous, and are arranged in superficial and deep sets, the former forming plexuses over the surface (sub-pleural lymphatics) and throughout the interlobular tissue, communicating with the cavity of the pleura by stomata, and the latter beginning in the mucous lining of the bronchial tubes and accompanying the vessels. The deep lymphatic vessels terminate in the *pulmonary lymphatic glands*, which are situated along the walls of the smaller bronchial tubes and in the angles of their divisions. There are about forty in the right lung and thirty in the left. The efferent vessels from these pulmonary glands join with the superficial lymphatic vessels and end in the *bronchial glands* which are clustered about the roots of the lungs and the lower portion of the bronchi and trachea. The efferent vessels from the bronchial glands communicate with the mediastinal glands, and are generally blackened by the deposition of carbonaceous matter. The right pulmonary lymphatics pass through the intermediation of the mediastinal glands to the right lymphatic duct, and the left pulmonary lymphatics join the thoracic duct.

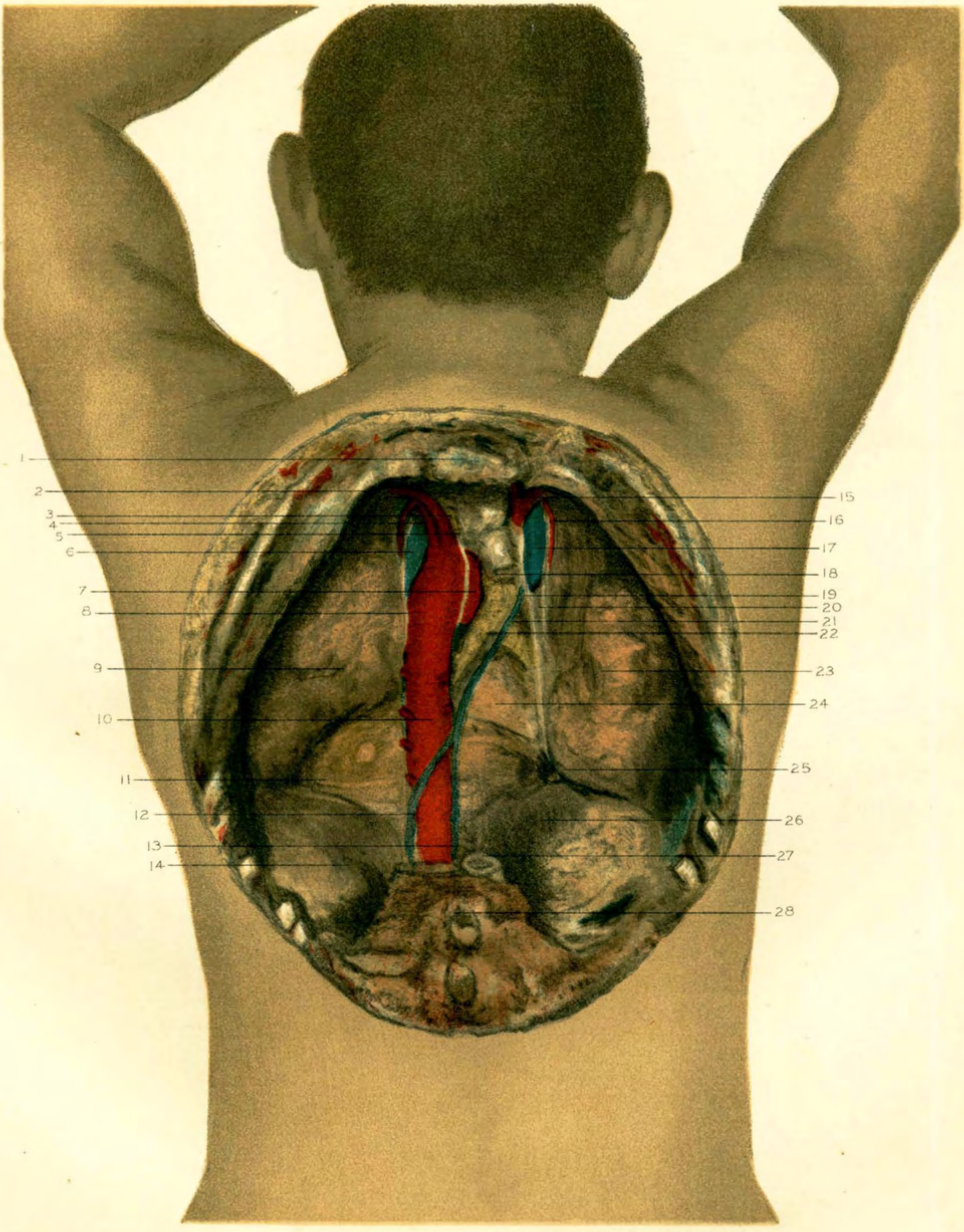
The *pulmonary nerves* are derived from the pneumogastric and sympathetic nerves on each side, which form the anterior and posterior pulmonary plexuses in front of and behind the roots of the lungs. They enter the lungs with the bronchial tubes and accompany their ramifications.

The pericardium, or heart-sac (Plate 34, and Plate 26, Fig. 1), is a dense fibrous pouch which encloses the heart and the portions of the great vessels which enter into and issue from its base. It is broadest below in relation to the diaphragm (page 320), where it is intimately adherent to the middle leaflet of the tendon about the opening for the inferior vena cava and more loosely connected to the muscular part on the left side. Above it passes into the superior mediastinum, enveloping the great vessels and becoming continuous with their sheaths. In this relation it also blends with the downward prolongations of the deep cervical fascia

PLATE 39.

View of the thoracic organs from behind, the dorsal vertebræ (from the second to the tenth) with portions of their contiguous ribs removed. The lungs are displaced to show the relations of the heart.

1. The body of the first dorsal vertebra.
2. The left subclavian artery.
3. The upper (cut) part of the thoracic duct ascending to empty into the left subclavian vein.
4. The left common carotid artery.
5. The left recurrent laryngeal nerve.
6. The left innominate vein.
7. The arch of the aorta.
8. The left phrenic nerve.
9. The left lung pushed aside and forward to show the position of apex of the heart resting on the diaphragm.
10. The thoracic aorta, with origins of the intercostal arteries.
11. The apex of the left ventricle of the heart within the pericardium.
12. The vena azygos minor.
13. The lower (cut) end of the thoracic duct coming through the aortic opening of the diaphragm.
14. The upper surface of the diaphragm on the left side.
15. The innominate artery, bifurcating into the right common carotid and subclavian arteries.
16. The right internal mammary artery.
17. The vena cava superior.
18. The upper (cut) end of the œsophagus.
19. The right pneumogastric nerve.
20. The right phrenic nerve.
21. The vena azygos major, emptying into the superior vena cava.
22. The bifurcation of the trachea into the right and left bronchi.
23. The right lung pushed aside and forward to show the relation of the left auricle of the heart and the arch of the diaphragm on the right side.
24. The left (or posterior) auricle of the heart.
25. The position of the inferior vena cava.
26. The upper surface of the diaphragm on the right side.
27. The lower (cut) end of the œsophagus.
28. The spine of the tenth dorsal vertebra.



Dissected, Photographed and Colored from Nature by George Mc Clellan, M.D.

Armstrong & Co. Lith. Boston.

(page 195), which are continued as dense bands (the suspensory ligaments) upon each side to their attachment at the diaphragm. These connections of the pericardium are of great interest, for if the entire diaphragm descends in respiration it must draw with it the heart-sac and therefore exert more or less strain upon the vessels at the base of the heart. The author inclines to the belief that the central portion or tendon of the diaphragm does not descend, although the lateral muscular portions do. On one occasion, after the excision of the sixth, seventh, and eighth ribs on the right side, he was able to examine the upper surface of the diaphragm during the forced efforts of inspiration under ether, and on another, after the evacuation of the contents of an enormous abscess involving the left lobe of the liver, he could easily introduce his hand into the abscess-cavity and detect the lateral upheaving of the diaphragm and the rapid pulsations of the heart. In the latter case, during the straining of the patient in the act of vomiting it was observed that the diaphragm descended and ascended with spasmodic contractions, but only upon the sides, there being apparently little if any change in the relations of its central tendon. There can be hardly any doubt that the direct connections of the pericardium below with the central tendon of the diaphragm and with the expansions of the deep cervical fascia above play an important *rôle* in maintaining the position of the arch of the aorta, and thus admitting of sudden changes of position without injurious interference with the circulation of the blood at its outset from the heart. The slight descent of the larynx noticeable on deep inspiration is probably due to the expansion of the chest walls and the consequent lateral traction exerted upon the bronchi by the distended lungs. The pleuræ overlap the pericardium in front, the right more so than the left (Plate 26, Fig. 1), and the phrenic nerves descend between them upon each side. Posteriorly the œsophagus is in close relation with that part of the pericardium which encloses the left auricle of the heart. After death the pericardium usually appears to be considerably larger than the heart, but this is due to the empty condition of the left side of the heart. In the healthy state, when the heart is distended, during life, it nearly fills the pericardium, except at the lower part on the left side of the diaphragm, where the sac covers the apex of the heart and is more or less loose. Although the pericardium is not ordinarily distensible, it may be made in the adult to hold about ten ounces of fluid, and in pericarditis with effusion the accumulation of serous fluid within the sac sometimes reaches a pint or more, which may be drawn off by tapping through the fourth or fifth interspace two centimetres, or about three-quarters of an inch, from either border of the sternum, so as to avoid the internal mammary vessels. The pericardium ordinarily contains several drachms of a clear straw-colored fluid.

The nutrient arteries to the pericardium are derived from the internal mammary, bronchial, and œsophageal arteries, and its veins mostly return their blood to the vena azygos. Its nerves are supplied by the phrenic nerves on both sides. If the pericardium is opened in front (Plate 35) the heart will be exposed glistening with the moist surface of a serous tissue which is reflected over it and the vessels at its base and also lines the fibrous sac. This serous tissue forms a shut sac, and is composed of a parietal layer in contact with the fibrous pericardium and a visceral layer in contact with the heart and interposed between the vessels so as to form a series of pouches. The invagination of the serous layer over the vessels is not always to the same extent, but there are usually seven tubular sheaths thus formed. There is a common reflection around the aorta and pulmonary artery, completely ensheathing them. The superior vena cava is also covered by the serous layer, except where it crosses behind the pulmonary artery. The inferior vena cava is covered only in front as it enters the right auricle directly after passing through the diaphragm. The left pulmonary veins are almost surrounded, and the right are only partially covered. The reflection of the serous layer is very irregular. The pouch which extends upward from the inferior vena cava on the right to the posterior surface of the left auricle is called the *great oblique sinus.* There are other, smaller pouches,—*i.e.*, between the inferior vena cava and the inferior right pulmonary vein, between the pulmonary veins, one on each side, between the upper right pulmonary vein and the superior vena cava, and one between the superior vena cava and the aorta, which, passing under the aorta and pulmonary artery, reaches the left side over the left auricle. This last, from its direction, is called the *transverse sinus.*

Besides these there is a fold between the left pulmonary artery and left pulmonary vein, of crescentic shape, two and a half centimetres, or about an inch, in depth, and two centimetres, or three-quarters of an inch, in length, which is the *vestigial fold*, and is the remains of the left superior vena cava of early fœtal life. These serous reflections enable the heart and the vessels at its base to maintain their freedom of action. That portion of the visceral layer of the pericardiac serous tissue which is closely connected with the intermuscular tissue of the heart-structure is distinguished as the *epicardium*. There are upon the surface many stomata which open from the plexus of lymphatic vessels, especially along the auricular margins. This layer also contains the nutrient vessels and nerves, which are usually associated with more or less fat along the grooves and deeper parts of this tissue. Even in health the amount of fat deposited upon the heart is often considerable; but this must not be confounded with the more serious condition of fatty degeneration of the muscular tissue.

The heart, as it appears upon opening the pericardium (Plate 35), is conical in form, and its surfaces are generally convex, with the exception of that portion which rests upon the pericardium where it is attached to the central tendon of the diaphragm, and which is flattened. It is situated obliquely as regards the middle line of the chest. Its base, to which the great vessels are attached, is directed upward and backward to the right side, where it is held firmly in relation to the spine between the fifth and ninth dorsal (thoracic) vertebræ by means of the dense cervico-thoracic fascia, which blends with the pericardium at the roots of the great vessels. Elsewhere the heart is free within the pericardium, and its apex is directed downward and forward to the left side, where during life it generally beats in relation to the interval between the fifth and sixth costal cartilages. The anterior surface of the heart consists mainly of the right auricle and right ventricle, which are brought into view when the pericardium is opened in front. The termination of the superior vena cava is also thus exposed as it enters the right auricle above, at the side of which is the ascending portion of the aorta curving upward and backward over the pulmonary artery, the root of which is overlapped by the appendix of the left auricle. Below the latter are the branches of the left coronary artery passing toward the apex of the heart in the groove between the left and right ventricles. On the right side the right coronary artery issues from beneath the appendix of the right auricle, which overlaps the root of the aorta. The apex is formed by the left ventricle, which projects a little beyond the right, so that normally its beat is felt against the chest wall. The posterior surface of the heart is formed chiefly by the left auricle and the left ventricle (Plate 43, Fig. 3).

As the relative position of the heart to the walls of the thorax is chiefly of value with reference to the normal location of the cardiac valves, it is thought best here to refer to the anatomy of the heart removed from the body (Plate 43), in order that a clearer idea may be obtained of the topographical survey of its relations *in situ*. The exterior of the heart presents more or less defined grooves which indicate the division of its interior into the four compartments called the auricles and ventricles. The *auriculo-ventricular groove* passes obliquely around the heart between the auricles and the ventricles. The *interauricular groove* separates the two auricles, and the *interventricular groove* separates the two ventricles, the anterior portion of the latter beginning under the left auricular appendix and ending to the right of the apex. The nutrient vessels, nerves, and lymphatics to the heart are chiefly lodged in these grooves embedded in fatty tissue beneath the epicardium, as already mentioned (page 275). The *right coronary artery* arises from the aorta upon the right side just after it issues from the heart-structure, and, passing between the pulmonary artery and the right auricle in the auriculo-ventricular groove, distributes branches to the contiguous vessels and portions of the right auricle and ventricle. The *left coronary artery* arises from the back of the aorta, a little higher than the right, and, passing between the pulmonary artery and the left auricle in the auriculo-ventricular groove, gives off several large branches which occupy the interventricular grooves and anastomose freely with the branches of the right coronary artery upon the outer surface. Within the substance of the organ the minute divisions of the coronary arteries terminate in capillary plexuses which empty into comparatively large venous radicles. It is an interesting fact that the origin of both coronary arteries is *above* the free borders of the aortic semilunar valves, the right being from the anterior sinus of Valsalva and the left from the left posterior sinus, so that there is a steady passage of the blood through them. The *coronary veins* receive their blood from the cardiac veins, which accompany the arteries and are provided with single valves where they are joined by their tributaries. They all end in the *coronary sinus,* which is two and a half centimetres, or about an inch, in length, situated at the back part of the auriculo-ventricular groove, and opens into the floor of the right auricle between the opening of the inferior vena cava and the auriculo-ventricular orifice. At its entrance into the auricle it is guarded by the *coronary valve.*

The shape of the heart varies during life, according to its dilatation or *diastole,* and its contraction or *systole,* but its vertical measurement is not altered by its action. The dimensions of the heart naturally vary with the age, sex, and general development of the individual. The average measurement of the heart of a well-developed adult male is twelve and a half centimetres, or about five inches, in length, from the base to the apex, eight and three-quarter centimetres, or three and a half inches, across the base, and six and a half centimetres, or about two and a half inches, in thickness, between the anterior and posterior surfaces. As a rule, the dimensions of the heart increase up to the age of fifty, and subsequently gradually diminish. The weight is generally about ten ounces in the male, and eight in the female, but depends upon the size and general condition of the body. The right border (*margo acutus*) is sharp and directed obliquely downward, while the left border (*margo obtusus*) is thick and rounded and directed obliquely upward. From the front of the right auricle a small pouch projects about the root of the aorta, which is called, from its resemblance to the ear of a setter dog, the *appendix auriculæ,* and from the upper side of the left auricle a similar appendix extends over the root of the pulmonary artery. When the adult heart is opened so as to display the interior of its cavities (Plate 43, Figs. 2 and 4) it appears to be a double hollow muscular organ, so constructed that each half, separated from the other by a septum, fulfils the function of a pump, for the propulsion of the blood in its circulation. The right half of the heart propels the venous blood to the lungs, the left propels the arterial blood throughout the body. Each half consists of two cavities, the auricle and the ventricle, communicating by an opening, the *auriculo-ventricular*, which is peculiarly guarded by valves. The auricles are the receptacles of the blood, and are provided with comparatively thin fleshy walls, which are always slightly thicker in the left than in the right. The ventricles, on the other hand, are composed of stout muscular walls adapted to their purpose of forcing outward the blood received from the auricles, their thickness being proportioned to the effort required of them. The left is therefore naturally thicker and stronger, as it distributes the arterial blood throughout the system, while the right sends the venous blood to the lungs. The *right auricle* consists of a main cavity, the *atrium* or *sinus venosus*, out of which extends the pouch called the appendix. When the anterior wall is removed the interior is exposed smooth and glistening, because it is lined with a delicate serous membrane, the *endocardium*, which is continuous with the serous coat of the vessels opening into the auricle, and through the opening into the ventricle below with the inner lining of the pulmonary artery. The *opening of the superior vena cava* is in the upper and anterior part of the auricle, about opposite the right auriculo-ventricular opening, so that the current of venous blood which it conveys from the upper part of the body is directed immediately to the ventricle. The orifice of the superior vena cava is the only large cardiac opening without a valve. The *opening of the inferior vena cava* is in the lowest part of the auricle, and, owing to the slight curve which the vessel takes after passing through the diaphragm, the venous blood which it returns from the lower part of the body is directed toward the oval depression, the *fossa ovalis*, in the auricular septum. The fossa ovalis indicates the position of the *foramen ovale*, which during fœtal life allowed the blood from the inferior vena cava to pass through into the *left* auricle. At that period this course of the blood was greatly assisted by the presence of the *Eustachian valve*, which is situated at the right margin of the opening of the inferior vena cava and extends to the front of the *annulus ovalis*, the prominent border surrounding the fossa. In the adult this valve appears as a thin crescentic fold of the endocardium, and often it has dwindled into a mere rudimentary band, simply indicating its former position. The floor of the fossa ovalis is the thinnest part of the septum between the auricles.

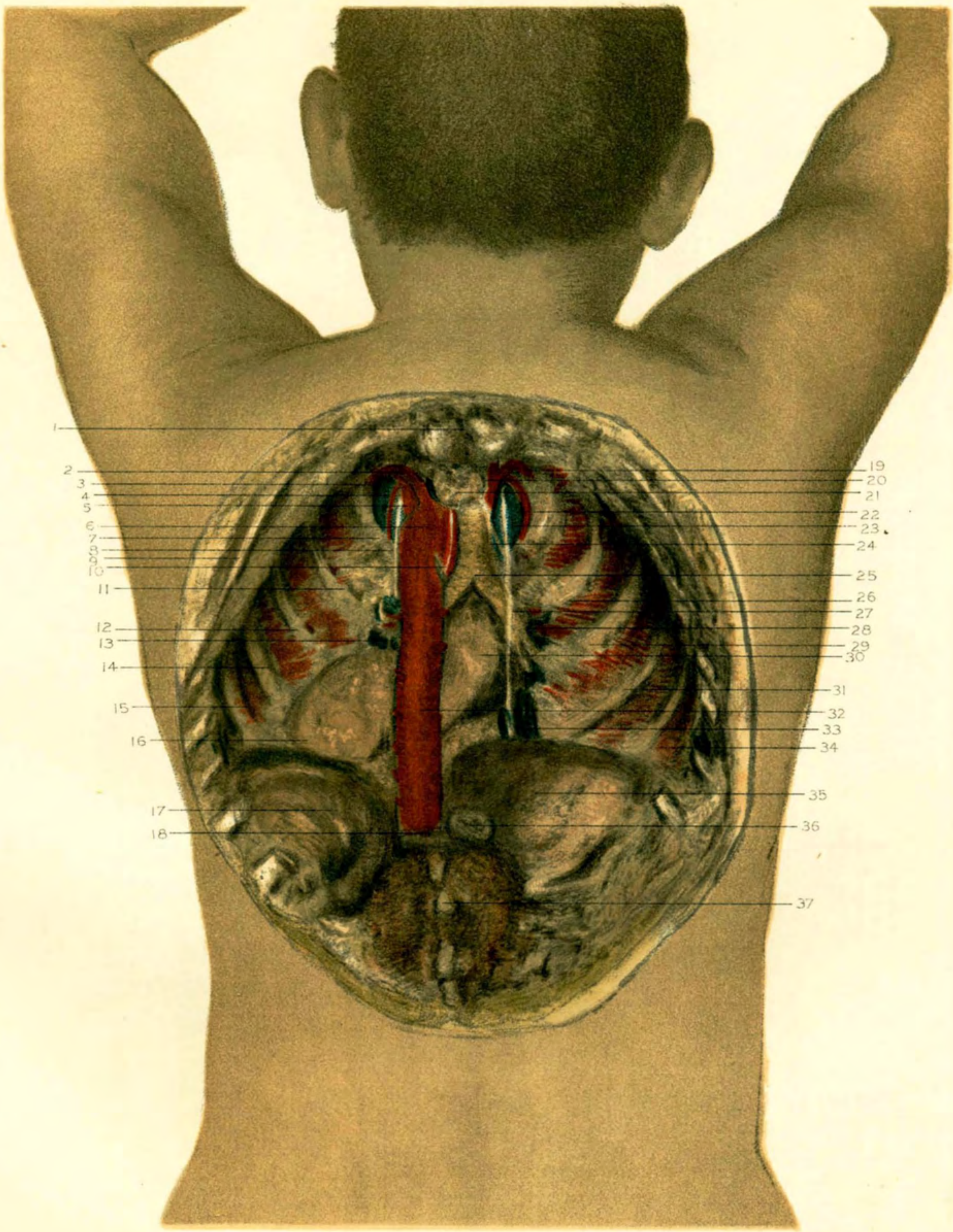
Between the remains of the Eustachian valve and the auriculo-ventricular opening is the *entrance of the coronary sinus,* which is quite large and is guarded by a duplicature of the endocardium, called the *valve of Thebesius..* Besides the sinus there are a variable number of little openings on the posterior wall of the auricle, called the *foramina Thebesii,* which are the minute apertures of little veins coming from the heart-substance. Some of these are impervious, but one, situated on the right of the septal wall, is constant, and known as the *vena Galeni cordis.* Interposed between the openings for the superior and inferior venæ cavæ there is a variable elevation termed the *tubercle of Lower,* which probably aids in the direction of the blood from the superior cava toward the auriculo-ventricular opening in embryonic life. Within the auricular appendix, and to some degree in the lower part of the atrium, there are parallel elevations of the muscular tissue covered with the endocardium, called, on account of their resemblance to the teeth of a comb, *musculi pectinati.*

The *right auriculo-ventricular opening* is of oval form, and large enough to admit three fingers. It is guarded by the *tricuspid valve,* which is named from the usual tripartition of the fibrous tissue of which it is composed, and invested by the endocardium; but this arrangement is often less pronounced than it is generally described as being. When the anterior wall is removed from the *right ventricle,* the objects within its cavity are exposed (Plate 43, Fig. 2). At the upper part there is a smooth passage leading to the opening of the pulmonary artery, called the *infundibulum,* or *conus arteriosus.* From the walls of the ventricle, which are everywhere thicker than those of the auricle, project bands of muscular tissue, the *columnæ carneæ,* of various character and arrangement. Some are short and thick, others are long and narrow. They are either mere ridges projecting from the walls, or constitute little bridges, having both ends attached and being free in the middle. There is usually a band extending from the ventricular septum to the anterior wall, called the

PLATE 40.

The normal position and relations of the thoracic aorta, seen from behind, the lungs being removed to show their roots.

1. The body of the first dorsal vertebra.
2. The left subclavian artery.
3. The left innominate vein.
4. The left internal mammary artery.
5. The left common carotid artery.
6. The arch of the aorta.
7. The left first rib.
8. The left phrenic nerve.
9. The vertebral border of the scapula.
10. The left recurrent laryngeal nerve winding upward round the aorta.
11. The left second rib, near its cartilage.
12. The left third rib.
13. The root of the left lung.
14. The left fourth rib.
15. The left fifth rib.
16. The apex of the left ventricle of the heart (within the pericardium).
17. The upper surface of the diaphragm on the left side.
18. The position of the aortic opening in the diaphragm.
19. The right subclavian artery.
20. The innominate artery.
21. The upper (cut) end of the œsophagus.
22. The right internal mammary artery.
23. The superior vena cava.
24. The right recurrent laryngeal nerve.
25. The trachea bifurcating into the right and left bronchi.
26. The right second rib.
27. The right pneumogastric nerve.
28. The root of the right lung.
29. The right third rib.
30. The left auricle of the heart.
31. The right fourth rib.
32. The thoracic aorta, with the roots of the intercostal arteries.
33. The inferior vena cava.
34. The right fifth rib.
35. The upper surface of the diaphragm on the right side.
36. The lower (cut) end of the œsophagus, where it passes through the diaphragm.
37. The spine of the tenth dorsal vertebra.



Dissected, Photographed and Colored from Nature by George Mc Clellan, M.D.

Armstrong & Co. Lith. Boston.

moderator, or a number of reticular fascicles taking its place, which prevents the complete reflection of the anterior wall.

The most important of the columnæ carneæ are those which are called the *musculi papillares*. There are three of these, usually well formed, in the right ventricle, corresponding in number to the flaps of the tricuspid valve. They are attached by one end to the walls of the cavity, and at the other terminate in the fine tendinous cords, the *chordæ tendineæ*, which regulate the action of the tricuspid valve. The two largest of the papillary muscles arise from the anterior wall of the ventricle, and the smallest from the septal wall. Occasionally accessory fasciculi are found interposed between the regular muscles and blending with them.

The auriculo-ventricular opening is surrounded by a ring of fibrous tissue which constitutes the base of the valve. The flaps of the valve are thinnest at their contiguous margins where they receive the chordæ tendineæ. Not unfrequently the edges of the flaps are jagged and irregular, and sometimes in the notches between them there are little projecting nodules. The *flaps* are designated according to their relative position as *right* and *left anterior* and *posterior*. The left anterior flap is the largest and freest, while the posterior is the shortest and least movable and is placed toward the septum. The chordæ tendineæ which are attached to the adjacent margins of the right and left anterior flaps and to the notch between them are furnished by the anterior papillary muscle; those to the adjacent margins of the right anterior and posterior flaps and to the intervening notch come from the posterior papillary muscle; and those to the adjacent margins of the left anterior and posterior flaps and to the intervening notch come from the smaller papillary muscle, which is derived from the septal wall and often augmented by independent chordæ which spring from the septum without any papillary muscle. The mode of attachment of the chordæ tendineæ to the flaps is of peculiar interest, as they serve to hold together the flaps of the valve during the systole of the ventricle and thus prevent the blood from regurgitating into the auricle. They are all fastened to the ventricular surface of the valve, and they severally separate into branches which go respectively to the base, middle, and free margins of the adjacent borders of the flaps as above described. Furthermore, the component fibres of the cords interlace with one another in the fibrous tissue of the valve. In the empty state of the ventricle the flaps appear hanging downward from the auriculo-ventricular opening, but experiment has shown that when the ventricle is full of fluid and is made to contract the fluid catches in the margin of the valve and presses the flaps upward and together, while the chordæ tendineæ act like little guy-ropes and prevent the flaps from turning upward into the auricle. Their proper adjustment and tension are brought about by the action of the papillary muscles, for without them they would be naturally slackened by the contraction of the walls of the ventricle.

At the upper part of the right ventricle the infundibulum leads into the common pulmonary artery, the mouth of which is guarded by three *semilunar valves,* of which one is situated anteriorly to the left and two are placed posteriorly to the right and left. At the upper and posterior surface of each valve the wall of the artery is dilated in a pouch, the *pulmonary sinus* (*of Valsalva*). The valves are formed of fibrous tissue continuous with the fibrous ring surrounding the opening, similar to the construction of the base of the auriculo-ventricular valve, and covered with a duplicature of the endocardium. The free margins of the valves are directed upward toward the lumen of the artery, and are each provided with a crescentic fibrous border, the *lunula,* in the middle of which there is a little blunt nodule of fibro-cartilage, called the *corpus Arantii.* The semilunar valves are readily forced upward by the blood during the ventricular systole, but when the ventricle relaxes the blood in the artery backs up against the valves, and, being received into the sinuses, exerts pressure upon the lunulæ of the valves, so as to bring them together, their closure being completed by the apposition of the nodules.

The *left auricle* is smaller than the right, but, like it, consists of a cavity, the *sinus,* and the auricular appendix. When the posterior wall is removed (Plate 43, Fig. 4) the interior of the sinus is seen to be covered with the endocardium, which is continuous with the lining membrane of all the openings leading in and out of the auricle, and through them with the internal coats of the vessels. Upon the posterior wall of the auricle are the *openings of the pulmonary veins*, usually four in number, two on the left and two on the right side, which return the oxygenated blood from the lungs. Sometimes the left pulmonary veins open by one orifice, more rarely by three. They are not guarded by valves. Upon the inter-auricular septum is a depression which indicates the position of the foramen ovale of fœtal life, which before birth admitted the venous blood brought by the inferior vena cava to the right auricle into the left auricle The *musculi pectinati* of the left auricle are fewer and smaller than in the right auricle, and are confined to the lower and back part of the cavity. The *left auriculo-ventricular opening* is of oval shape and a little smaller than the right, and is placed at the lower and anterior part of the auricle. It is guarded by the *bicuspid* or *mitral valve*, which has two flaps, one anterior and to the right, and one posterior and to the left, with little nodules projecting at their notches, called the *nodi valvulæ mitralis*. The right flap is the larger. The interior of the left ventricle presents a close resemblance to the right. Its walls are very thick, especially in their upper portion, where they are also broadest, but they gradually diminish toward the apex. The *columnæ carneæ* are smaller, more reticulated, and more numerous than in the right ventricle. Two large, variably-constituted papillary muscles project from among the columns at the bottom of the cavity, the anterior from the left wall and the posterior from the right. They terminate in *chordæ tendineæ*, which are attached to the flaps of the mitral valve. The construction of the mitral valve corresponds to that of the tricuspid valve, but it is thicker and stronger in all its component parts. The ring of fibrous tissue surrounding the auriculo-ventricular opening, the flaps themselves, and the chordæ tendineæ are all stronger. The latter are similarly attached to the adjacent margins of the flaps, the posterior papillary muscle supplying the adjacent margins on the right, and the anterior papillary muscle furnishing the adjacent margins on the left. They are both reinforced by additional cords from the contiguous portions of the walls with or without muscular origin. The action of the mitral valve is apparently the same as that of the tricuspid,—*i.e.*, to prevent regurgitation of the blood into the auricle during the systole of the ventricle. From the upper and back part of the left ventricle a smooth surface leads to the *opening into the aorta,* which resembles that of the pulmonary artery, having *three semilunar valves,* with dilatations of the aortic wall (*sinuses of Valsalva*) behind them. The aortic opening is placed in the groove between the two auricles, and it is very close to the left auriculo-ventricular opening, being separated from it only by the larger anterior flap of the mitral valve. In framework and construction the aortic semilunar valves differ from those guarding the pulmonary artery only in being proportionately stronger, to adapt them to the greater work they have to accomplish, consistently with the greater strength of the left ventricle, in sending the arterial blood throughout the general system.

The *structure of the heart* consists of an intricate arrangement of layers of muscular fibres supported upon a framework of fibrous tissue. The latter is disposed in rings about the two auriculo-ventricular, the aortic, and the pulmonary openings, as described in their proper relations. These rings, besides forming the bases for the attachment of the valves, receive at their external circumference the muscular fibres of the walls of the different cavities. The strongest part of the *fibrous skeleton* is in the interspace between the aortic and the two auriculo-ventricular openings. This is triangular, and in some of the lower animals is substituted by a bony nodule, called the *os cordis.* The *muscular fibres of the heart* are peculiar for the comparatively small amount of connective tissue between the component fascicles, which are of the striped variety and very closely associated. They are arranged in layers, whose striæ pass transversely and longitudinally. The fibres of the auricles are distinct from those of the ventricles. They consist of a *superficial layer,* which generally runs across the base of the heart, including both auricles, and a *deep layer,* composed of fibres surrounding the auricular appendix and the entrances of the venæ cavæ on the right auricle, and the auricular appendix and the entrances of the pulmonary veins on the left. The superficial fibres are most marked on the anterior surface, and send a few fasciculi inward to the interauricular septum. The deep fibres also blend with the muscular fibres of the ventricles in front and behind the auriculo-ventricular fibrous rings. The layers of fibres composing the *walls of the ventricles* are very complicated, and can be satisfactorily studied only after hardening by prolonged boiling, which dissolves the connective tissue. These fibres are independent of the auricles, and are much thicker. They consist of various layers, which for the most part commence from the rings of the fibrous framework above and descend obliquely to the apex of the heart, twisting upon one another in such a manner as to produce what is called the *vortex*, and ascend in the interior of the walls back again to the fibrous rings, sending off in their courses fibres which constitute the columnæ carneæ and musculi papillares. The most superficial layer of the ventricular fibres in front of the heart descends obliquely across from right to left, many of those from the right at the anterior interventricular groove turning inward and intersecting with the fibres in the ventricular septum which arise from the deeper layers. Behind the heart the fibres descend from left to right, and do not enter at the posterior interventricular groove. The deeper layers of fibres which compose the chief bulk of the ventricular walls are arranged in strata, whose fascicles vary in the degree of their obliquity, diminishing from without inward, and interlacing everywhere, so that they present fibres which have been described as making annular or figure-of-eight loops. Some of the deeper layers of fibres do not appear to have any connection with the fibrous rings. The most valuable inference to be drawn from the laborious efforts of investigators, who have attempted to unravel the complications of these muscular fibres, is that the musculi papillares are integral parts of the walls from which they spring, so that they contract simultaneously with them.

The *nerves of the heart* are derived from the pneumogastric and from its recurrent branch, and from the three cervical sympathetic ganglia on both sides (page 219), which form the *great cardiac plexus* in front of and behind the arch of the aorta. This consists of numerous, minute, and delicate nerves, which interlace in every direction with one another, and are known, from their relative position, as the *superficial* and *deep cardiac plexuses* (Plates 36 and 37). In relation to the concavity of the aortic arch there is sometimes found a small ganglion (the *cardiac ganglion of Wrisberg*). Both the superficial and deep cardiac nerves form frequent connections with each other, and thus establish the *pulmonary plexuses*

PLATE 41.

Figure 1.

The thorax of a young female, with the second, third, fourth, fifth, and sixth ribs removed on the left side, and the left lung drawn aside to show the relations of the root of the lung and the apex of the heart to the diaphragm.

1. The manubrium of the sternum.
2. The cartilage of the left second rib.
3. The left internal mammary artery with its two companion veins.
4. The cartilage of the left third rib.
5. The cartilage of the left fourth rib.
6. The cartilage of the left fifth rib.
7. The left first rib.
8. The upper lobe of the left lung.
9. The root of the left lung.
10. The left phrenic nerve.
11. The coronary artery.
12. The lower lobe of the left lung.
13. The apex of the heart.
14. The relation of the phrenic nerve to the apex of the heart.
15. The diaphragm.
16. The left seventh rib.
17. The diaphragm seen between the left eighth and ninth ribs.

Figure 2.

Transverse section through the thorax of an adult male, on a level with the lower borders of the third ribs anteriorly and through the body of the eighth dorsal vertebra posteriorly, seen from below.

1. Section through the gladiolus of the sternum.
2. The right internal mammary vessels.
3. The anterior mediastinum.
4. Section through the right third rib.
5. The superior lobe of the right lung.
6. The right ventricle of the heart.
7. The right auricle of the heart.
8. Section through the right fourth rib.
9. The right phrenic nerve.
10. The middle lobe of the right lung.
11. Section through the right fifth rib.
12. The œsophagus.
13. The vena azygos major.
14. The inferior lobe of the right lung.
15. Section through the right sixth rib.
16. Section through the right seventh rib.
17. The right eighth rib.
18. Spine of the eighth thoracic vertebra.
19. The left internal mammary vessels.
20. The anterior margin of the superior lobe of the left lung.
21. The superior lobe of the left lung.
22. The left ventricle of the heart.
23. The left phrenic nerve.
24. Section through the left fourth rib.
25. Section through the left bronchi.
26. The left pneumogastric nerve.
27. The thoracic duct.
28. The descending aorta.
29. The inferior lobe of the left lung.
30. The body of the eighth thoracic vertebra.
31. The spinal canal with section of the spinal cord.
32. The eighth thoracic vertebra.
33. The left eighth rib.
34. Section through the dorsal muscles.

Fig 1

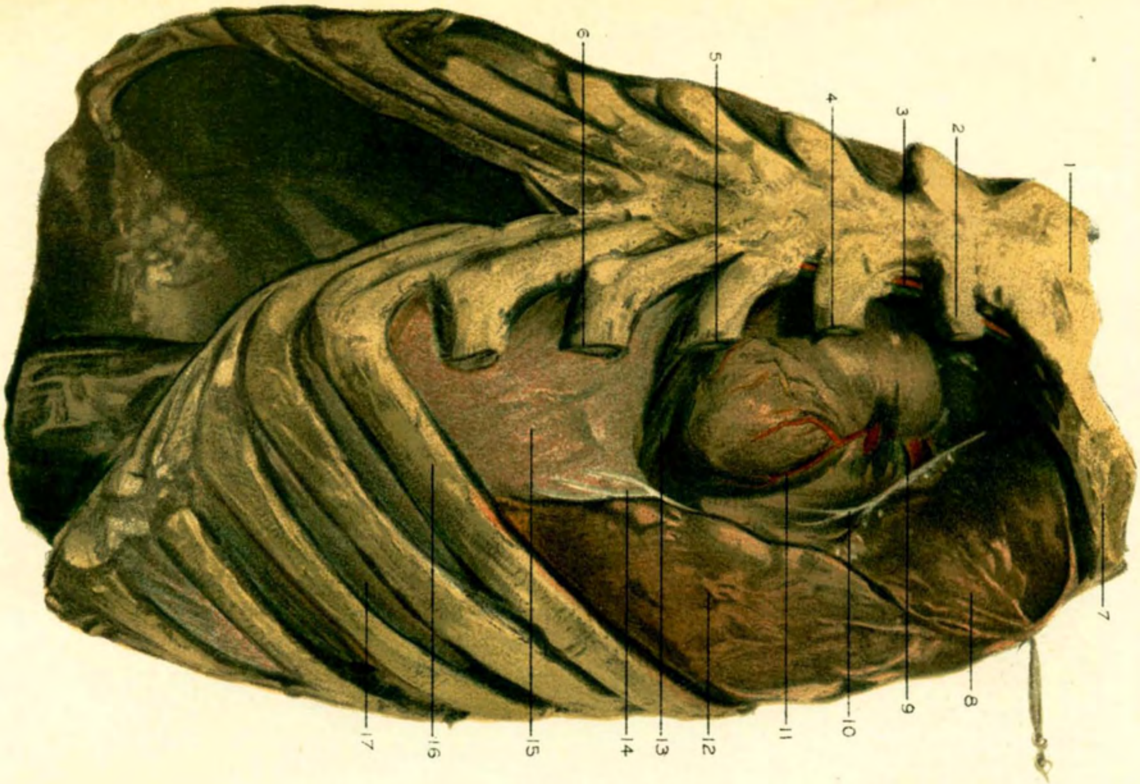
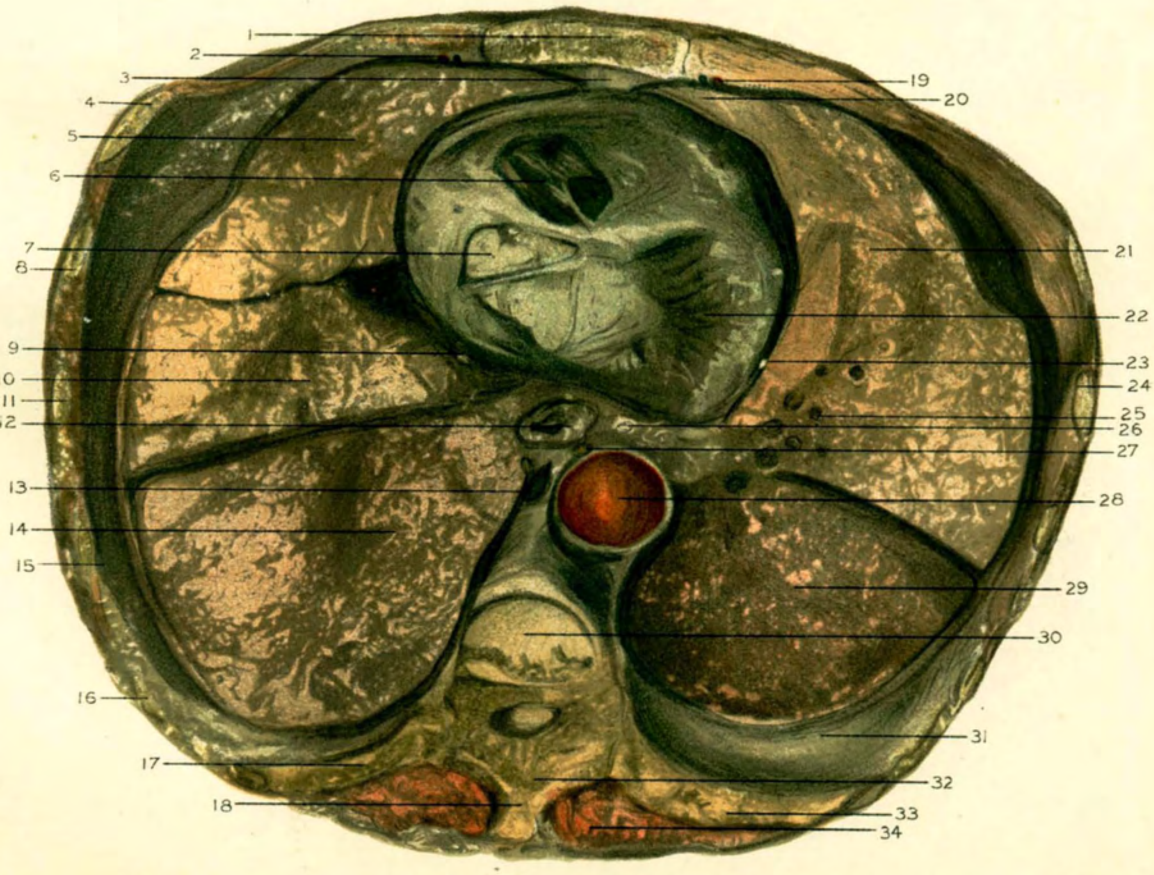


Fig 2



Dissected, Photographed and Colored from Nature by George Mc Clellan, M.D.

Armstrong & Co. Lith Boston.

in relation to the roots of the lungs, and the *coronary plexuses.* The branches of the latter respectively accompany the ramifications of the coronary arteries both without and within the substance of the heart. It is said that there are minute *intra-cardiac ganglia,* which possibly preside over the functional contractions of the heart.

The *lymphatic vessels of the heart,* which also occupy for the most part the interventricular grooves with the vessels and nerves, convey their lymph to the glands situated between the aorta and the trachea, and thence pass to the right lymphatic duct and the thoracic duct on either side of the root of the neck.

The *superior vena cava* (Plate 35) is formed by the right and left innominate veins (page 222), which unite opposite the first intercostal space on the right of the border of the sternum, and descends, with a slight inclination backward, to the right auricle, which it enters at its upper and anterior part, opposite the third right costal cartilage. It is six and a quarter centimetres, or about two and a half inches, in length, in the adult, and the lower portion is covered with the pericardium (Plate 34). Above it is covered on the right side by the pleura, between which and the great vein the phrenic nerve passes downward. The superior vena cava is without valves, and receives, besides some pericardiac and mediastinal veins, the *vena azygos major,* which curves downward over the right bronchus above the pericardium (Plate 37, No. 30).

The aorta (Plates 33, 35, 36, 40, 42, and 43) arises opposite the lower border of the *third* costal cartilage, at the upper and posterior part of the left ventricle, near the centre of the heart. Its normal course is very singular, and its shape much resembles that of an old-time shepherd's crook. At its commencement it is expanded into a *bulbous enlargement,* in consequence of the dilatations (the sinuses of Valsalva) opposite the semilunar valves at its cardiac orifice, and proceeds upward about five centimetres, or two inches, and a little to the right of the middle line, as high as the lower border of the second right costal cartilage. This portion is called the *ascending* (or *ventral*) *aorta,* and is enclosed in the fibrous layer of the pericardium. It is in very close relation with the under surface of the sternum, the lower margin of the thymus gland and the right pleural sac being interposed between them. The bulbous enlargement is covered by the pulmonary artery on the left, being included with it in a common sheath of the serous layer of the pericardium, and by the appendix of the right auricle on the right (Plate 35). The ascending aorta encroaches somewhat upon the superior vena cava, and is in relation posteriorly to the right pulmonary vessels and the root of the right lung. The coronary arteries to the heart are given off from the origin of the aorta, as already described (page 276). Near the termination of the ascending portion the aorta usually presents a dilatation, the *sinus maximus,* which changes the lumen of the vessel in that situation from circular to oval. It is worthy of especial note that the first or ascending part of the aorta is closely covered only by the thin serous layer of the pericardium, which renders an aneurism in this locality very dangerous, in consequence of the easy, rapid distention of the coats of the vessel and the slight hinderance to the escape of the blood into the pericardium.

From the lower border of the second right costal cartilage the aorta passes backward, at first a little upward and to the left, toward the body of the second dorsal vertebra, and then, curving across the trachea just above its bifurcation, it turns downward at its left side as far as the lower border of the fourth dorsal (thoracic) vertebra. This portion is called the *transverse aorta,* or *arch of the aorta.* Its relations are very important and interesting. On the left it is overlapped by the left pleura, beneath which the left phrenic nerve passes, and it is in close proximity to the left pneumogastric nerve, which here gives off the left recurrent laryngeal nerve (Plates 36 and 40), which curves upward under the aorta (page 186). On the right it is in contact with the right pleura, and posteriorly it is very near the trachea, œsophagus, and thoracic duct. From the upper surface of the arch of the aorta the three normal branches arise close together,—*i.e.,* the *innominate artery* (page 221), the *left common carotid artery* (page 223), and the *left subclavian artery* (page 229). Their origins are crossed by the left innominate vein (Plate 35). The orifices of the innominate and the left common carotid, when examined from within the aorta, are separated by merely a sharp edge. The cardiac nerves from the sympathetic and pneumogastric nerves also pass over the arch to their distribution on the heart (page 219). This portion of the aorta measures four and three-quarter centimetres, or a little less than two inches, in length. The highest point to which its convex surface reaches in a well-formed adult is usually about two and a half centimetres, or an inch, below the upper border of the sternum, and its concavity corresponds with the ridge between the manubrium and the gladiolus; but these points cannot be definitely relied upon, as various factors may tend to raise or lower the arch, and it is subject to modifications owing to interference with its proper development.

There are various irregularities of the great vessels which probably occur more frequently than has been noted, and may be ascribed to either an arrest or a persistence of one or other of the primitive aortic arches of early embryonic life, out of the ordinary order of the human development. Such modifications usually result in transposition of the innominate to the left side or some change in the point of origin of the carotid or the subclavian artery upon one or both sides. Anomalies of the heart and the aorta are extremely rare. It may not be inappropriate to mention in this connection such a case which the author met with in the body of a man aged twenty-seven years, whose death was caused by phthisis. The preparation (Plate 26, Fig. 4) exhibits *no arch of the aorta*, but independent origins of both right and left carotid and subclavian arteries from the top of the descending thoracic aorta, with the heart placed vertically, the position in which it was found within the chest. This disposition of the aortic branches is somewhat analogous to that ordinarily observed in the horse and in the ruminating animals, but it does not appear to have been hitherto recorded as found in man. The heart was found to consist of a single auricle and a single ventricle.

The *common pulmonary artery* (Plate 35), which conveys all the venous blood from the right side of the heart, to be aerated in the lungs, commences at the infundibulum in the upper part of the right ventricle (page 279). This vessel is nearly five centimetres, or two inches, in length, and, as has been already stated, is contained within the sheath of the serous layer of the pericardium, which is common to it and the ascending portion of the aorta. It stands out in front of all the great cardiac vessels when the heart-sac is opened between the right and left auricular appendages (Plates 33 and 35). Its direction is upward and backward to the concavity of the arch of the aorta, where, in front of the bifurcation of the trachea and on a level with the sixth dorsal vertebra, it divides into the right and left pulmonary branches, which, passing through the pericardium on each side, enter the roots of the respective lungs. The *right branch* is larger and longer than the left, and is separated from the arch of the aorta by the deep cardiac nerves of that side, and as it enters the root of the right lung it is in front of and *below* the right bronchus (page 268). The *left branch* passes in front of the descending aorta and enters the root of the left lung in front of and *above* the left bronchus (page 269). Where the left branch leaves the pericardium there is a short fibrous cord extending backward to the left end of the arch of the aorta, which is the remains of the *ductus arteriosus*, the canal by which, in fœtal life, the blood from the pulmonary artery passed directly into the aorta (page 304). The *pulmonary veins*, which return the blood to the left auricle of the heart after it has been re-oxygenated and transformed into *arterial blood* in the lungs, commence in a net-work of capillary vessels upon the walls of the air-vesicles, where they are continuous with the ultimate ramifications of the pulmonary artery (page 270). They also receive part of the blood distributed by the bronchial veins in the substance of the lungs. They unite at first into single trunks corresponding to each lobule, and these in turn unite to form a trunk for each lobe, so that the right lung has three and the left lung two main efferent vein-trunks. Usually the two upper trunks of the right lung join at its root, although they sometimes remain independent of each other. The right pulmonary veins are somewhat longer than the left, and they all terminate in the posterior wall of the left auricle (page 283), the orifices of those coming from the left lung being closer together and on a lower level than those from the right. The upper one of the right and the lower one of the left are respectively larger (eighteen millimetres, or three-quarters of an inch, in diameter) than their companion veins. Both pairs in the roots of the lungs (page 268) occupy a position in front of the pulmonary arteries, and as they pass horizontally toward the left auricle they pierce the pericardium, the serous layer of which is reflected over their anterior surface. There are no valves in the pulmonary veins.

As the heart is the central organ of the vascular system, in which, by means of the great vessels at its base, the arteries originate and the veins terminate, the general anatomy of these two classes of the blood-vessels may be here properly considered.

The arteries are comparatively firm, elastic tubes, which commence at the heart in two great trunks, the aorta (page 287) and the pulmonary artery (page 289), the former distributing the arterial blood from the left ventricle throughout the general system, and the latter conveying the venous blood from the right ventricle to the lungs, as described on page 306.

The *systemic arteries* arise from the main branches of the aorta, which are directed to the head and the extremities and to the various organs of the body. The arteries generally pursue the shortest, most direct, and most protected course from their origins to the locality of their distribution, and this is particularly noticeable in the extremities, where they are contiguous to the bones, in the lines of flexure, so that they are less exposed to injury and less likely to be compressed by muscular action. The arteries (except within the tissues of the brain and of the bones) are provided with a special investment of the areolar tissue of the parts in which they are contained, constituting their sheaths, and in particularly exposed situations the superficial arteries are usually further protected by tendinous expansions. They also continue of uniform size until they give off a branch, when they become, as a rule, somewhat smaller in calibre. It has been estimated, however, that the combined capacity of the branches is greater than that of their original trunks, and in consequence there is naturally a diminution in the velocity of the blood-current as it proceeds farther and farther from its source. In certain localities, where the parts are freely movable, the arteries are tortuous, so that they readily accommodate themselves to changes in position and the movements of the soft parts without being subjected to strain. The facial, lingual, and vertebral arteries are examples. Arteries branch in various ways. If they divide into two equal branches, they diverge at equal angles from the line of the trunk. If the branches are unequal, the trunk is deflected from its straight course to the side opposite that to which the branch is distributed, varying in degree according to the size of the branch. In fact, the branches may be given off at any angle, but they usually proceed at an acute angle from their origin. In their course the smaller arteries frequently communicate with one another, constituting what is called their *inosculation* or *anastomosis*. This arrangement serves to prevent an interruption in the flow of the blood in case of pressure upon one or other of the branches, and is of great value in the establishment of the *collateral circulation* after the ligation of any one of the principal vessels.

In the brain, the retina, and the kidneys the ultimate branches of the arteries are called *terminal* or *end arteries*, because they do not anastomose with one another, and consequently if a supplying artery is blocked by an embolus the area of its distribution is completely destroyed by necrosis.

During life the arteries possess a considerable degree of elasticity and contractility, as is often witnessed in the remarkable manner in which they escape injury in penetrating and incised wounds. In the healthy state the walls of the arteries are capable of withstanding a considerable degree of intravascular tension, and their firmness is conspicuous, for when they are cut across they do not collapse, as the veins do. They appear empty after death, and on this account were originally supposed to contain air. The elasticity of the arteries diminishes with age, and in consequence they often become spirally twisted and tortuous in localities where they are loosely embedded in the tissues. The size of the arteries is proportionate to the amount of blood required by the *physiological actions* of the part which they supply. The larger arteries (eight millimetres, or three-eighths of an inch, in diameter) are attended by a single large vein; the medium-sized arteries (six millimetres, or one-quarter of an inch, in diameter) have one or two accompanying veins, and the smaller (three millimetres, or one-eighth of an inch, in diameter) usually two veins. The *venæ comites* of the arteries are generally included in their areolar sheath, together with the nerve-cord which passes to the same area of distribution as the artery.

The course of the arteries in the extremities is generally along the intermuscular septa, or in the spaces between the superficial and deep muscles, so that a twig issuing among the surface-tissues, if traced backward, serves as a guide to the position of the main vessel. By this means, for example, the anterior and posterior tibial arteries within the deeper part of their course may be easily found; and there is no safer way of reaching the external iliac artery than by following the deep epigastric, or of reaching the axillary artery than by following the acromial. Owing to some localized arrest of development, occasioning dilatations of anastomotic branches and attended by contraction or obliteration of the main trunk, there are frequent *variations* in the arteries, and it often happens that a vessel which is usually small may become abnormally enlarged, so that it is liable to be mistaken for the main artery. It should be remembered also that a small branch arising from a large vessel will always bleed freely, and to an extent out of proportion to its size, so that its hemorrhage requires to be promptly arrested.

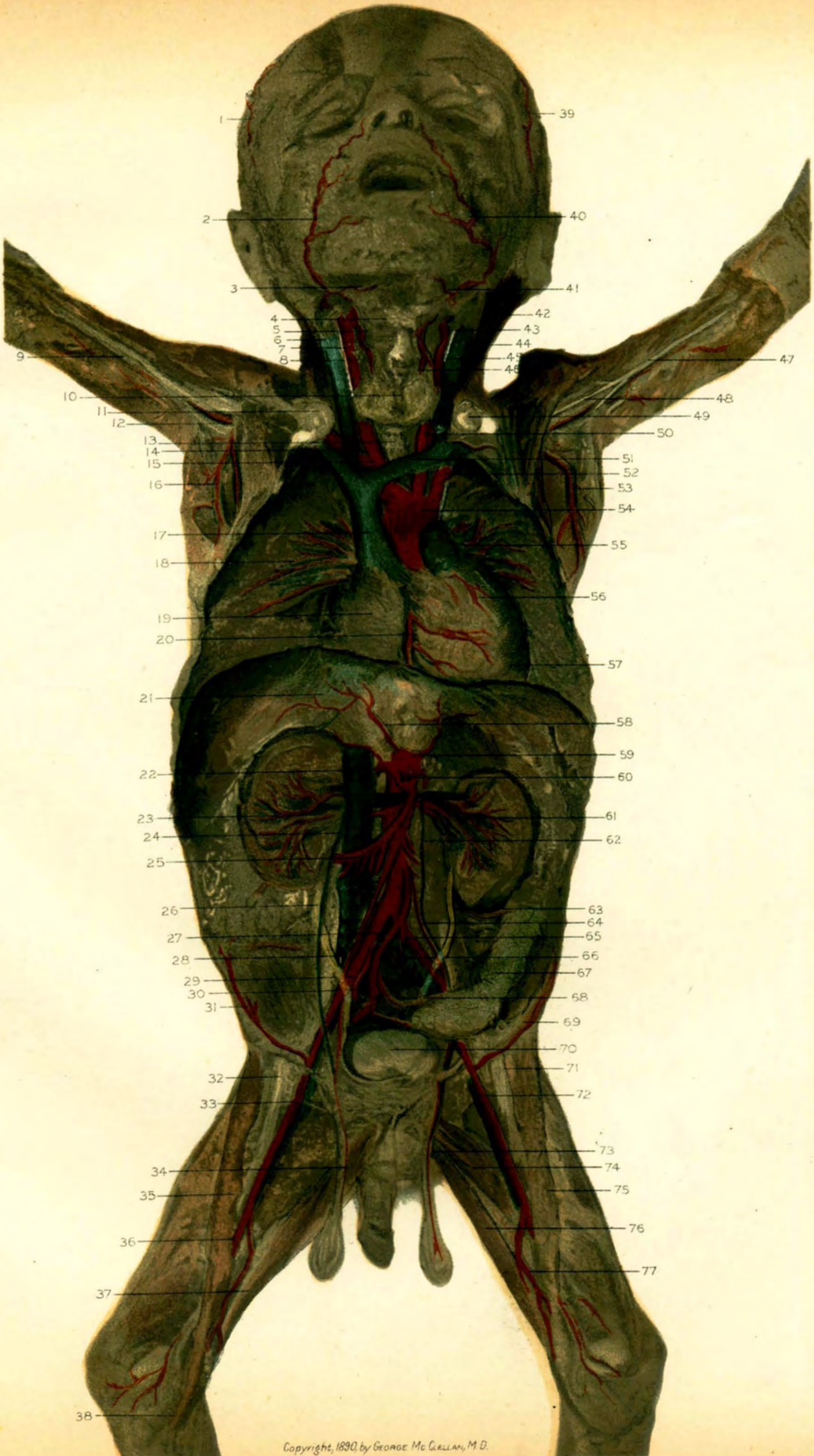
The *structure of the walls of the arteries* consists of three chief layers of various formation which are intimately associated with one another. They are called the external, middle, and internal coats, or the tunicæ adventitia, media, and intima. The *external coat*, or *adventitia*, on which the strength and firmness of the arteries mainly depend, is composed of layers of condensed fibro-connective tissue derived from the surrounding cellular tissue and arranged in interlacing bundles, between the meshes of which are lymph-spaces and connective-tissue corpuscles. In the larger vessels, and in the arteries which are loosely connected with their surroundings, as on the face and the mesentery, longitudinal muscular fibres are blended with the other elements of the outer coat, which in the latter case not only renders the mesenteric arteries thicker but enables them to offer support to the parts which they supply, the jejunum and the ileum, and to withstand the constant traction to which they are subjected in the changes of position of the intestines during life. The *middle coat*, or *media*, is the thickest portion of the wall of an artery. It consists principally of unstriped muscular fibres (and therefore is sometimes also called the *muscular coat*), with a variable quantity of elastic connective-tissue fibres.

PLATE 42.

Dissection of the vascular system in a child eight months old, showing the principal arteries and veins in their proper relations and positions.

1. The right temporal artery.
2. The right facial artery.
3. Branch of the right lingual artery.
4. The body of the hyoid bone.
5. The superior, or descending, thyroid artery.
6. The right internal jugular vein.
7. The right common carotid artery.
8. The right pneumogastric nerve.
9. The median nerve of the right arm.
10. The thyroid body.
11. The sternal end of the right clavicle.
12. The axillary artery.
13. The trachea, at the root of the neck.
14. The right subclavian vein, branching from the right innominate vein.
15. The right innominate vein.
16. The right subscapular vessels and nerves.
17. The superior vena cava.
18. The root of the right lung, showing the pulmonary vessels.
19. The right auricle of the heart.
20. The anterior coronary artery and veins.
21. The under surface of the diaphragm, showing the right phrenic arteries.
22. The inferior vena cava.
23. The right kidney, opened, showing the renal vessels.
24. The right spermatic vein, emptying into the inferior vena cava.
25. The superior mesenteric artery, drawn to the right side.
26. The right ureter.
27. The right common iliac artery.
28. The right spermatic artery.
29. The right internal iliac artery.
30. The inferior mesenteric artery.
31. The right circumflex iliac artery.
32. The right anterior crural nerve.
33. The right femoral vessels, passing under Poupart's ligament.
34. The right spermatic cord.
35. The sartorius muscle.
36. The femoral artery, passing into Hunter's canal.
37. The gracilis muscle.
38. The insertion of the sartorius, gracilis, and semitendinosus muscles.
39. The left temporal artery.
40. The left facial artery.
41. The left lingual artery.
42. The left sterno-mastoid muscle.
43. The left pneumogastric nerve.
44. The left internal jugular vein.
45. The left common carotid artery.
46. The left superior thyroid artery.
47. The median nerve and brachial artery of the left arm.
48. The axillary artery, surrounded by the cords of the brachial plexus.
49. The sternal end of the left clavicle.
50. The left carotid artery.
51. The left innominate vein.
52. The left subclavian artery.
53. The left subscapular vessels and nerves.
54. The arch of the aorta.
55. The root of the left lung, showing the pulmonary vessels.
56. The posterior coronary artery.
57. The apex of the heart.
58. The left phrenic artery, on under surface of the diaphragm.
59. The abdominal aorta.
60. The cœliac axis.
61. The left kidney, opened to show the renal vessels.
62. The left spermatic vein, emptying into the renal vein.
63. The left ureter.
64. The left spermatic artery.
65. The left internal iliac artery.
66. The inferior mesenteric artery.
67. The sigmoid flexure of the colon, drawn aside.
68. The superior hæmorrhoidal, or rectal, artery.
69. The left circumflex iliac artery.
70. The bladder.
71. The left anterior crural nerve.
72. The left femoral vessels.
73. The left spermatic cord.
74. The left adductor longus muscle.
75. The left sartorius muscle.
76. The left gracilis muscle.
77. The anastomotica magna artery.

N. B.—The preparation from which the photograph for this plate was taken is remarkable because it is an actual demonstration of the circulation of the blood. The injection, a solution of wax in ether, was introduced into the right common carotid artery beneath the lobe of the thyroid body, and, having passed through the capillaries, filled the veins. There is some probability that the foramen ovale had remained unclosed, which would have contributed to complete the venous injection. The ductus arteriosus was obliterated.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77

They are arranged for the most part circularly, except in the smallest arterioles, where they are spiral. The proportion of the elastic tissue apparently diminishes with the size of the artery, while the converse is true with regard to the muscular tissue, so that the smaller vessels possess greater contractility relatively to the larger. Connective tissue also enters into the construction of this coat in the larger vessels, and many of the latter are provided with an external elastic lamina (Henle). The muscle-fibres in the middle coat of the large arteries are irregular and both oblique and longitudinal, while in the small arteries they are more uniform and exhibit under the microscope longitudinal striæ each containing an elliptical nucleus. The *internal coat,* or *intima,* is very delicate and thin, and composed of an intermixture of elastic and fibrous tissue arranged in several layers. The amount of elastic tissue also varies with the size of the vessel, being in the smallest merely a single layer. The internal surface of the intima consists of the transparent membrane, the *endangium,* which closely resembles the serous membranes in character and is continuous with the endocardium of the heart. The endangium has been demonstrated to be constituted of two layers, called the *endothelium* and the *membrana propria.* The former consists of a single stratum of transparent fusiform cells having a central nucleus and arranged parallel to the course of the vessel. The latter consists of interlacing connective-tissue fibres containing branching corpuscles. The amount of muscle and elastic tissue in the walls of certain arteries is variable irrespective of their calibre, as it has been proved that the carotid and axillary arteries are provided with more elastic tissue in their middle coats than the femoral, which has a greater quantity of muscle-fibre.

Upon the application of a ligature to an artery in the healthy state the internal and middle coats are completely broken, so that they retract, while the external coat is puckered up.

The arteries are without valves.

The veins possess much thinner walls and are generally larger in calibre than the arteries. They return the venous blood from the system by means of the superior and inferior venæ cavæ (pages 287 and 306), and from the walls of the heart by the coronary sinus (page 277), to the right auricle, and the arterial blood from the lungs by the pulmonary veins (page 290) to the left auricle. The *systemic veins* are more numerous than the arteries, and their combined capacity is greater. They originate in radicles, which receive the blood from the capillaries everywhere in the tissues, and are generally arranged in plexuses at their commencement. From these plexuses branches are given off which unite into trunks, which are constantly increased in size by being joined by tributaries in their course toward the heart. They consist of two chief divisions, the *superficial* and the *deep veins*. The former are placed between the layers of the superficial fascia beneath the skin, and the latter accompany the arteries, being known as the *venæ comites*, or *satellites*. The largest arteries and their largest branches are usually accompanied by a single vein, but the medium-sized and smaller arteries have two veins, which are enclosed in their common sheaths, as previously described (page 292). In certain regions, as in the brain, the spinal canal, and the liver, the veins do not accompany the arteries; in others, as in the head and face, they pursue a more direct course than the arteries. The veins communicate or inosculate much more freely than the arteries do, even among those of large size. This is conspicuous with the superficial veins, which form a network over the whole body. The intercommunication of the superficial veins with the deep is especially noticeable at the flexures of the joints, where the motions would otherwise be liable to offer impediment to the flow of the blood. This is also markedly the case in the neck and within the cranium, where any obstruction to the venous system would be followed by a dangerous stasis.

The veins of the dura mater within the head are called the *sinuses*, which are formed by the splitting of that membrane and lined by epithelium (page 18). In certain localities where veins are contained within masses of areolar tissue and enveloped in a dense fibrous membrane, they may anastomose, but as their walls are imperfect they allow their blood to escape into the surrounding trabeculæ or spaces and thus form *erectile tissue*, as in the *corpora cavernosa penis*. The veins offer very many anomalies, but there is always a noticeable fact regarding them,—*i.e.*, that where a vein is unusually small there is a compensating enlargement in an adjoining or neighboring vein. Such a variation is commonly noticed between the external and anterior jugular veins (page 192). The *structure of the walls of the veins* is composed, like that of the arteries, of three coats, but taken together they are less uniform and thinner than the arteries, although they are more intimately connected. They possess considerable strength, however, and the walls of the superficial veins are generally thicker than the deeper ones. It is very difficult to separate the *external* and *middle coats.* The former consists chiefly of a compact layer of fibro-connective tissue blended with meshes of elastic fibres. The latter is mostly made up of irregular circular bands of unstriped muscular tissue, also held together in meshes of elastic fibres. The amount of fibro-connective and muscular tissue varies in the veins of different parts, and the two tissues hold variable proportions to each other in the outer and middle coats. In the great jugular and innominate veins at the root of the neck there is a deficiency of muscular tissue. In the Haversian canals of the bones the walls of the veins consist only of fibrous tissue lined with endothelium.

The *internal coat,* or *intima,* of the veins is very similar to that of the arteries, consisting of a very delicate elastic membrane, having upon its internal surface an endothelial lining and a substratum of striated connective tissue, often containing muscle-cells. One of the most important peculiarities of the veins is the development of *valves* from their internal coats in certain localities, which prevent regurgitation of the blood and therefore assist its passage toward the heart. They usually occur in pairs, placed opposite each other in the course of a vein, but are single at the orifices of the branches. The valves are not found in all veins, but they are most numerous in the superficial veins of the extremities, especially the lower, where they often appear like knots through the skin in varicosed conditions. They consist of crescent-shaped flaps composed of the inner coat, like little pockets. They are attached with their convex border to the sides of the vein and their free concave margin directed in the proper course of the blood, so that if this is interfered with by pressure and a reflux occurs the pockets become filled and close the lumen of the vein by their distention. The valves are not always equally developed, as on several occasions the author has found it possible to throw ar injecting material into the radicles of the hand or foot through the main venous channel of the limb: in two instances a solution of wax in ether was thus made to traverse the capillaries and fill the arteries.

The relative position which the main arterial and venous trunks bear to one another throughout the body follows the rule already mentioned (page 222), that above the diaphragm the veins are superficial to the arteries, while below the diaphragm the arteries are superficial to he veins, with the single exception of the renal veins.

The capillaries are the fine hair-like vessels which serve as the secret communications by which the blood passes continually from the arteries into the veins throughout the tissues of the various organs of the body. They are so minute that they can be seen only with the microscope, and so fine that it is necessary to rupture several of them to get a drop of blood. Although generally very numerous, they vary in number in the different tissues according to their requirements for nutrition, being most abundant in the tissues or organs where the greatest degree of vital activity exists. They are not found in the cartilages, epithelium, or epidermis. Ordinarily they are arranged in a system of net-works, which vary in the size of their meshes in different localities. They are very close in the lungs, in the gray substance of the brain and spinal cord, in the mucous membranes generally, and in the muscular and adipose tissues. In the dermis and choroid coat of the eye the net-work of capillaries is exceedingly fine and close. In the fasciæ, however, and the aponeuroses, tendons, and ligaments, the capillary meshes are wider, the vessels themselves being fewer. They are variably arranged to conform with the structure of the tissues which they occupy. This is noticeable especially in the lungs in relation to the lobules, and in the papillæ of the skin or the villi throughout the intestinal canal. In their simplest form the capillaries may be considered as composed only of the delicate endothelial lining of the arteries or veins with which they are continuous. They are both elastic and contractile, so that they differ in calibre under different conditions. Under the influence of chemical reagents their walls have been shown to have a cellular construction, with the cells arranged longitudinally to the axis of the vessel. The cells contain an oval nucleus, and they are held together by what is termed "intercellular cement," which is marked at intervals by fine dots. During the state of inflammation the capillaries become distended, and the intercellular cement in the localities of these dots yields, occasioning small openings in the walls, the *stomata*, through which the white blood-corpuscles show a tendency to escape into the interspaces among the tissues. This is an important characteristic of these vessels, as by its means the elements of nutrition in the processes of growth, repair, and performance of function are imbibed and eliminated. When the capillaries in the web of a frog's foot or in the mesentery of a snake are examined under the microscope, they appear as transparent tubes containing a clear fluid (*liquor sanguinis*), which moves more slowly along the walls of the vessels, being retarded by friction, than in the centre, where the corpuscles are arranged in a column and are swept onward with greater rapidity. It follows from the resistance offered by the increased wall-area of the capillaries, as well as by the minuteness of their lumina, that the blood circulates through the capillaries much more slowly than it does in the large arteries. In some tissues the blood-vessels, before they terminate in capillaries, divide into peculiar tufts of minute anastomosing vessels, such as are seen in the glomeruli or Malpighian corpuscles of the kidney. In others the separate arterial stems and venous radicles form a net-work before they break up into capillaries, and thus constitute the different forms of *rete mirabile*, such as occur in the choroid tela and velum interpositum of the brain. The walls of all the larger arteries and veins are provided with arteries and veins of their own, the *vasa vasorum*, which are derived from and terminate respectively in the neighboring vessels. It is evident to the naked eye that such vessels are furnished to the external coats of the large vessels, and it is asserted that the microscope has revealed that there are capillary vessels in relation also to the middle coat. Lymphatic vessels appear, as already stated, in and around the external coats, and about the largest vessels they establish plexuses.

The arteries and veins are also supplied with nerves, the *vaso-motor nerves*, which form plexuses in the muscular or middle coats, more especially of the arteries. They have been shown to preside over the contractility and dilatability of the vessels, and explain many of the physiological phenomena, as in pallor or blushing, and the changes in local temperature, owing to their influence upon the degree of blood-pressure. The vaso-motor nerves, although apparently derived as fibres from the sympathetic ganglia in the various regions of the body, have been demonstrated by experiment, in many instances, to arise originally from the nerves of the spinal cord. The so-called *inhibitory* or repressing effect manifested in the physiological action of certain drugs is probably ascribable to them. These nerves are now considered as consisting of two distinct sets of fibres, which from their opposing influences are called *vaso-constrictor* and *vaso-dilator nerves.* The marvellous rapidity with which the secretion and excretion of certain organs are performed, and the regulation of the distribution of the blood by which the various physiological processes of digestion are determined, can be understood only by taking into account the controlling influence of this special division of the intricate nerves, composed of fibres from the sympathetic and fibres from the spinal nerves combined, and probably presided over by some special centre in the floor of the fourth ventricle of the brain.

The blood is the viscid, red-colored, opaque, alkaline fluid which circulates throughout the vascular system, and the function of which is to furnish the nutritive material to all the tissues and organs of the body, and to eliminate from them many of the elements of waste which are capable of being revivified and used over again. The color of the blood varies according to the conditions under which it is seen, and in the different sets of vessels in which it flows, being bright red in the arteries, and bluish-black or purple in the veins. These changes of color are due to the amount of oxygen which is in combination with the *hæmoglobin,* the coloring-matter of the blood. The blood has a saline taste and a peculiar odor. Its material is in a continual state of change and motion, the degree of the latter being regulated by the influence of the vaso-motor nerves and the calibre of the vessels in which it is contained.

The blood consists essentially of cellular elements, the *corpuscles,* and an intercellular substance, the *plasma.* The corpuscles are of two kinds, the *white,* or *leucocytes,* which are variable in number in different parts and in different conditions of the individual, and the *red corpuscles*, which in health always greatly outnumber the white and give to the blood its characteristic color. The *leucocytes* are colorless, nucleated cells, which under the microscope show amœboid motions. The *red corpuscles* are uniform, homogeneous, flattened circular disks, concave upon both surfaces and without nuclei. There are also in the blood a quantity of minute oval disks, called *blood-plates*, and numberless granules, *hæmatoblasts*. The *plasma* is a clear, colorless, alkaline fluid, which is capable of transudation through the walls of the capillary vessels into the surrounding cellular spaces of the connective tissue. These spaces are now called *lymph-paths*, because the lymph is formed within them as the result of the combination of unused plasma and waste tissue-cells. The lymphatic system of vessels is described with the lacteals, in connection with the anatomy of the intestinal canal, in Vol. II.

When fresh blood is examined at the temperature of the body, the *white corpuscles* are seen to change slowly their shape and position, resembling in many respects the microscopic animalcule the amœba. This power of *amœboid movement* enables the white corpuscles under certain influences to pass out with the plasma into the cellular spaces; and hence these corpuscles are also known as the *migratory cells*. The white corpuscles are in fact derived from the lymph, and are supposed to be the source of the red corpuscles; but this has not yet been satisfactorily established. The *red corpuscles* in fresh blood exhibit a remarkable tendency to pile themselves together like little rouleaux of coin. The *plasma* consists chiefly of a permanent liquid, the *serum*, which is a straw-colored fluid, and of certain elements called fibrin-factors, *fibrinogen* and *fibrino-plastin*. When the blood is withdrawn from the body and at rest, there is apparently a ferment formed from the breaking down of some of the white corpuscles, which occasions the union of the fibrin-factors into a clot, or coagulum. The *serum* is an albuminous solution containing salts, fatty matters, sugar, etc., and readily coagulable by heat. The blood also contains in solution oxygen, carbonic acid, and nitrogen gases. The *hæmoglobin*, or coloring-matter, belongs to the red corpuscles, and has a remarkable affinity for oxygen, which it absorbs when

PLATE 43.

Figure 1.

The front view of the heart removed from the body, with the roots of the great vessels arising from the aorta.

1. The trachea.
2. The ima thyroidea artery.
3. The right common carotid artery.
4. The right subclavian artery.
5. The innominate artery.
6. The superior vena cava.
7. The ascending portion of the arch of the aorta.
8. The right coronary artery.
9. The right auricle.
10. The appendix of the right auricle.
11. The left subclavian artery.
12. The left common carotid artery.
13. The transverse portion of the arch of the aorta.
14. The descending portion of the arch of the aorta.
15. The common pulmonary artery.
16. The appendix of the left auricle.
17. The left coronary artery.
18. The right ventricle.
19. The left ventricle.
20. The apex of the heart.

Figure 2.

Section of the *right* auricle and ventricle to show the interior of their cavities.

1. The ima thyroidea artery.
2. The right common carotid artery.
3. The right subclavian artery.
4. The innominate artery.
5. The ascending portion of the arch of the aorta.
6. The superior vena cava.
7. The foramina Thebesii.
8. The opening of the vein of Galen.
9. The annulus ovalis.
10. The fossa ovalis.
11. The tubercle of Lower.
12. The Eustachian valve.
13. The orifice of the coronary vein.
14. The musculi pectinati.
15. The inferior vena cava.
16. The right common carotid artery.
17. The right subclavian artery.
18. The transverse portion of the arch of the aorta.
19. The descending portion of the arch of the aorta.
20. The appendix of the left auricle.
21. The pulmonary artery laid open.
22. The semilunar valves.
23. The cut edge of the right ventricle.
24. The anterior musculus papillaris.
25. A bristle passed through the right auriculo-ventricular opening.
26. The chordæ tendineæ.
27. The inter-ventricular septum.
28. The columnæ carneæ.
29. The apex of the heart.

Figure 3.

The posterior view of the heart in relation to the thoracic aorta.

1. The left common carotid artery.
2. The left subclavian artery.
3. The descending portion of the arch of the aorta.
4. The pulmonary artery.
5. The appendix of the left auricle.
6. The posterior coronary artery.
7. The thoracic aorta.
8. The apex of the heart.
9. The right common carotid artery.
10. The right subclavian artery.
11. The transverse portion of the arch of the aorta.
12. The superior vena cava.
13. The dilatation situated at the entrance of the inferior vena cava into the right auricle.
14. The inferior vena cava.

Figure 4.

The posterior walls of the *left* auricle and ventricle removed to show the interior of their cavities.

1. The aorta.
2. The pulmonary artery.
3. The musculi pectinati.
4. The appendix of the right auricle.
5. The anterior flap of the mitral valve.
6. The left coronary artery.
7. A needle passed through the aortic opening.
8. The apex of the heart.
9. The left pulmonary veins.
10. The right pulmonary veins.
11. Openings of the pulmonary veins in the wall of the left auricle.
12. The septum.
13. A bristle passed through the left auriculo-ventricular opening.
14. The appendix of the left auricle.
15. The posterior flap of the mitral valves.
16. The musculus papillaris.
17. The columnæ carneæ.

N. B.—The specimen from which these four plates were taken was the heart of an adult male, perfectly healthy and normal, excepting the little ima thyroidea artery, which arises from the innominate, as seen in Figures 1 and 2.

Fig 1

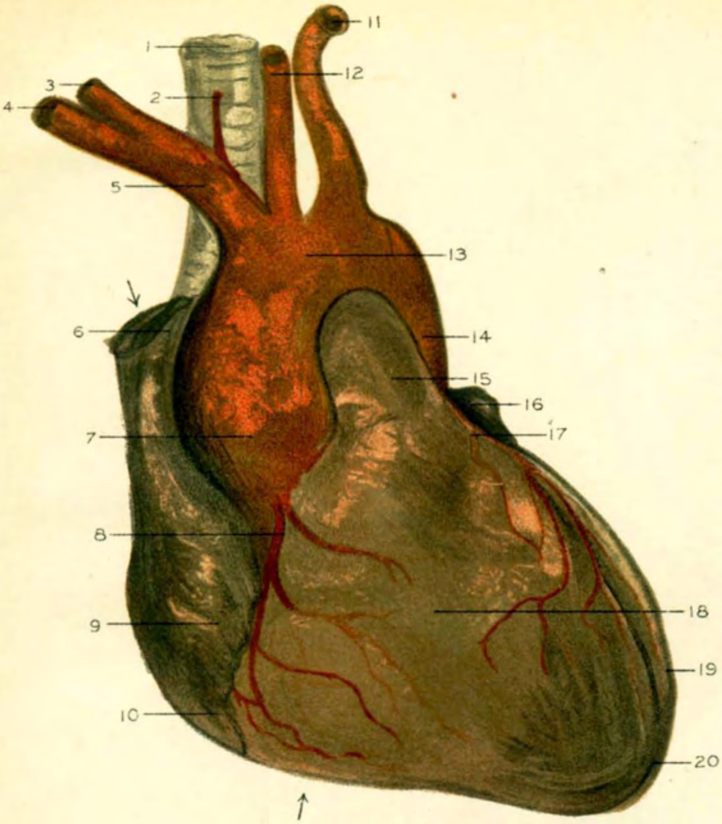


Fig 2

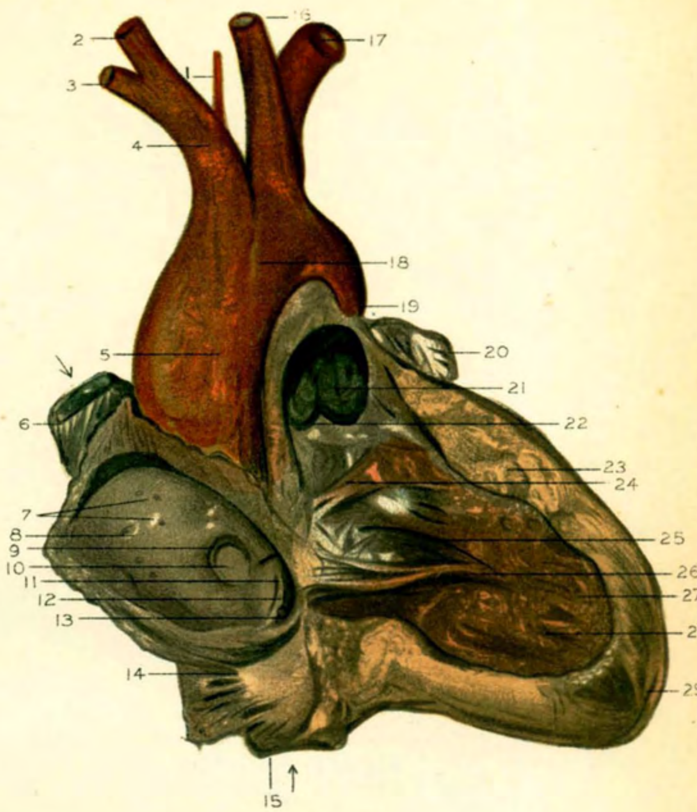


Fig 3

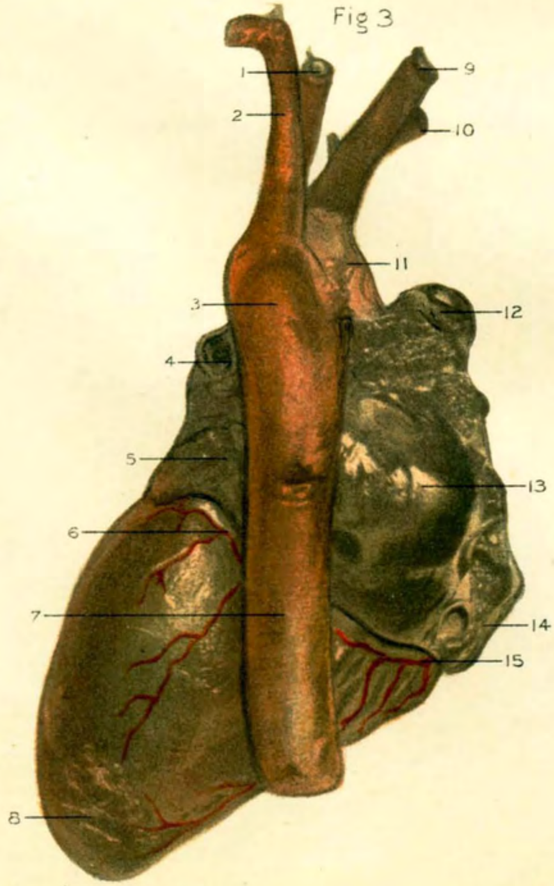
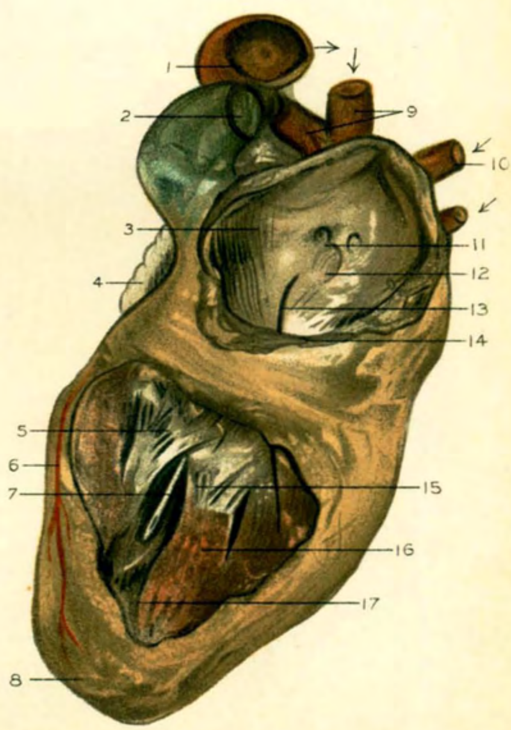


Fig 4



Dissected, Photographed and Colored from Nature by George Mc Clellan, M.D.

Armstrong & Co. Lith. Boston.

brought into relation with the air-cells of the pulmonary lobules by endosmosis.

The fœtal heart, and the circulation of the blood before birth.—In the early stages of the fœtal formation the heart occupies nearly the whole of the thoracic cavity, and, comparatively speaking, is much larger than it is subsequent to birth. The auricular portion exceeds the ventricular, and the right auricle is more capacious than the left, the right ventricle being also smaller than its fellow. The organ is placed vertically within the thorax in its early stages. Just before birth, however, these peculiarities disappear, and the ventricular portion becomes the larger, the left having the thicker walls, and the whole organ rapidly approaches its normal condition for life. The internal structure of the *fœtal heart* is different from that of the adult chiefly in having an oval opening (*foramen ovale*) between the auricles, which allows a communication from side to side, and in the large size of the *Eustachian valve* (page 278), which directs the blood from the inferior vena cava through the foramen ovale. The latter generally becomes closed within the first week or ten days after birth, but may remain open longer, and in some instances has been found to be slightly pervious at a great age. The Eustachian valve speedily dwindles after the establishment of the function of the lungs and the proper circulation of the blood. Contemporary with these structural alterations changes occur in the great vessels which are requisite for the independent circulation of the blood. The pulmonary artery of the fœtus, after leaving the right ventricle, gives off the right pulmonary branch, and then divides into two other branches, the first of which is as large as the pulmonary artery itself, about twelve millimetres, or half an inch, in length, and directly joins the aorta at the termination of its arch (page 290), while the other goes to the left lung. The connecting branch between the pulmonary artery and the aorta is named the *ductus arteriosus.* It is really the continuation of the pulmonary artery.

The *fœtal circulation* (Plate 26, Fig. 2) consists of the entrance of the *arterial* blood from the placenta into the body of the embryo at the umbilicus, by means of the *umbilical vein,* which ascends to the under surface of the liver.

Within this organ the greater part of the blood first communicates with the branches of the portal vein and with the hepatic veins, and thence passes to the inferior vena cava, but a portion of the blood conveyed by the umbilical vein is conducted by a small vessel directly to the upper part of the inferior vena cava, without passing through the substance of the liver: this vessel is called the *ductus venosus* (Plate 26, Fig. 2, No. 5). The inferior vena cava empties all its blood into the right auricle, whence it is directed by the Eustachian valve through the foramen ovale into the left auricle. From the left auricle it passes through the left auriculo-ventricular opening into the left ventricle, and thence by means of the aorta it is distributed chiefly to the head, neck, and upper extremities. The more immediate supply of pure blood to these parts accounts for their greater proportionate development at birth. The impure blood from the upper part of the body is returned into the superior vena cava, and by it to the right auricle, from which it passes through the right auriculo-ventricular opening into the right ventricle. From the latter it issues by the pulmonary artery, and is chiefly conveyed by its continuation, the *ductus arteriosus* (Plate 26, Fig. 2, No. 13), into the upper portion of the descending aorta, where it mixes probably with some of the blood from the left ventricle passing through the arch of the aorta. From the descending aorta the blood passes through the abdominal aorta into the iliac arteries. The external iliac arteries carry part of this blood to the lower extremities, but most of that in the internal iliac arteries is curiously returned to the placenta by means of the *hypogastric arteries*, which are the continuations of the superior vesical branches of the internal iliac arteries (Plate 26, Fig. 2, Nos. 22 and 24). They pass out at the umbilicus, where, under the name of the *umbilical arteries*, they twine round the umbilical vein in the substance of the cord, and return their impure blood to the placenta to be re-oxygenated. The umbilical vein and the ductus venosus become empty at birth, contract, and are ultimately converted into fibrous cords which occupy the fissure of the ductus venosus of the liver and become its round ligament. They are usually obliterated about the fifth day after birth. The ductus arteriosus and the hypogastric arteries also contract after birth, and become closed, the former usually within the first ten days, and the latter within the first three or four days. The remains of the ductus arteriosus constitute the *ligamentum arteriosum*, which is attached to the concavity of the aorta at the left end of the arch. The bands resulting from the obliteration of the hypogastric arteries form the lateral false ligaments of the bladder.

The *lungs previous to birth* are quite solid, and are packed into the back parts of the recesses on each side of the thorax. They receive only a slight amount of blood by their proper branches of the pulmonary artery, and return it to the left auricle by the pulmonary veins.

The changes in the heart and vascular system, upon which depends the differentiation of the circulation of the blood before and after birth, are all gradual and commensurate with the processes of development. They are almost completed by the establishment of the function of the lungs when respiration occurs and the connection with the placenta is severed. At birth, the first inspiratory effort appears to be due to the stimulus of the atmosphere upon the surface nerves, which is immediately imparted to the pneumogastric and phrenic nerves, in consequence of which the phenomena of respiration ensue. The first expansion of the lungs is attended with the passage of blood through the pulmonary veins into the left auricle, which exerts a considerable degree of pressure upon the septal valve, so as to bring it in contact with the margin of the foramen ovale, and thus the blood is directed through the left auriculo-ventricular opening into the left ventricle. Coincident with this is the diminution of the tension between the auricles, owing to the arrest of the incoming blood from the umbilical vein, so that there is little obstacle to the blood from the inferior vena cava joining that from the superior vena cava in its passage through the right auriculo-ventricular opening into the right ventricle. The expansion of the lungs in inspiration induces the suction of the blood from the right ventricle into the pulmonary artery and from the left ventricle into the aorta. The passage of the blood through the ductus arteriosus ceases with the determination of the pulmonary circulation and the mechanical influence exerted upon the vessels at the root of the heart through their connections with the deep cervical fascia.

The circulation of the blood after birth, when the organs have attained their full development, consists in the reception of all the venous blood returned from the body through the venæ cavæ into the right auricle and its passage into the right ventricle, whence it is propelled through the right and left branches of the pulmonary artery into the lungs. Here the blood is subjected to the purifying influence of the air within the lobules (page 269), and then returned by the pulmonary veins to the left auricle. This constitutes the *pulmonary circulation*. The propulsion of the arterial blood from the left ventricle by means of the aorta to be distributed throughout the body, and its return by the capillaries into the veins which conduct it to the right auricle, constitute the *systemic circulation*. The latter, in reality, consists of numerous small circulations everywhere, each of which is made up of supplying arteries, intervening capillaries, and draining veins. In its passage to and from the heart the blood is propelled in a rhythmic current in consequence of the peculiar elastic and muscular contraction of the walls of the ventricles. As it is forced through the openings between the cavities or at the orifices of the vessels leading out of them, every impulse is followed by the closure of the various valves which normally prevent the regurgitation of the blood, and thus characteristic sounds are produced.

The heart-sounds in health consist of a long sound (*lūb*), succeeded by a short one (*dŭp*), which is immediately followed by a pause equal in duration to the second sound; and then the long and short sounds are repeated, and so on. The *first sound* is caused chiefly by the closing of the auriculo-ventricular valves, with the accompanying rush of the blood from the ventricles in consequence of their systole or contraction. This is synchronous with the beat of the apex against the chest wall. The *second sound* is produced by the abrupt closure of the semilunar valves which follows upon the emptying of the ventricles at the close of their contraction, and by the pressure of the blood upon them, which, after it has been driven into the pulmonary artery and the aorta, is forced into the sinuses of Valsalva in its endeavor to return. The degree of the pressure upon the semilunar valves, which is proportionate to the volume of the blood in the great vessels, causes the distinctness with which the second sound is heard, and accounts for what is called its *accentuation*.

Both the right and left ventricles contract and dilate in unison, as both the right and left auricles also do.

The *arterial pulse* is produced by, and coincident with, the ventricular contraction, as may be ascertained upon auscultation and feeling the pulse in any one of the superficial arteries at the same time. In consequence of this the second sound, which is produced by the simultaneous closing of the pulmonary and aortic semilunar valves, may be usually heard with the stethoscope placed over the carotid arteries at the root of the neck, as it is propagated in the blood-current from their origins. If a murmur is detected during the ventricular systole it is probably due to regurgitation of the blood from the pulmonary artery or the aorta, or to some obstruction at one of the auriculo-ventricular openings. If in connection with this there is absence of the second sound over the carotids, aortic regurgitation may be inferred. The prolongation of the first or second sounds, called their *reduplication*, is due to the want of harmonious closure of the flaps of the respective valves producing them. When both the auricle and the ventricle upon one side become dilated from any cause, great tension is exerted upon the fibrous ring to which the base of the auriculo-ventricular valve is attached, and it is rendered "incompetent." The tricuspid valve is peculiarly constructed so that regurgitation may take place through it whenever the right ventricle is in any way embarrassed, and the *third flap* of this valve has on this account been compared to a "safety arrangement," as it provides this means of relief from the strain that would otherwise be exerted upon the pulmonary capillaries. Disease of the tricuspid valve is rare, probably on account of this anatomical provision, but when it allows of regurgitation of the venous blood back into the right auricle it is often associated with a pulse in the jugular veins. This is more especially noticeable in the right jugular vein, as the reflux blood passes more readily into the right innominate vein. What is called the *respiratory pulse* is often observable in the superficial cervical veins, even in health, after rapid exercise, as in dancing, when, during the rapid efforts at expiration and inspiration, and before harmonious respiration is regained, the blood is prevented from emptying itself evenly from the veins into the superior vena cava. As the left side of the heart is always engaged in forcing the arterial blood throughout the system, it naturally follows that the *mitral valve* is liable to suffer in consequence of over-work. *Mitral regurgitation* is therefore the most frequent of valvular affections, and the murmur which characterizes it necessarily occurs with the ventricular systole. This murmur can be distinguished from aortic regurgitation by not being noticeable in the carotid arteries, but by being more clearly heard over the apex and below the left shoulder-blade, where the left ventricle is nearest the thoracic wall without the intervention of any other portion of the heart.

In order to determine upon a **topographical survey of the chest** (Plate 27) for the clinical study of the relative positions of the important parts of the heart and lungs, it is well to bear in mind certain established facts, and to pay especial attention to the landmarks of this region. There is very little possibility of change in the normal position of the *base* of the heart in the adult, as has been explained (page 273), in consequence of the manner in which the pericardium is attached to the central tendon of the diaphragm below and to the deep cervical fascia above.

The *apex* of the heart, on the contrary, is continually changing its position during life, as it is free within the pericardium, and extends upon the left muscular arch of the diaphragm, which overlies the stomach, so that not only does it naturally accommodate itself to the diaphragmatic movements of respiration, but its freedom is also somewhat interfered with when the stomach is distended. In this connection it should be remembered that the left lobe of the liver overlaps the stomach, even so far as its cardiac extremity, and thus intervenes between the latter and the diaphragm (Plate 29). Distention of the stomach with gas from fermentation in digestion in various dyspeptic conditions is often attended with cardiac disturbance, but this disturbance occurs chiefly through the tension exerted upon the diaphragm and the consequent limitation of the ordinary moving space of the heart within the pericardial sac. Undoubtedly, also, many of the nervous symptoms attendant upon such a condition may be ascribed to the dragging upon the filaments of the pneumogastric nerves which accompany the œsophagus through its proper opening in the diaphragm to their distribution over the stomach (Plate 36). The degree of displacement of the heart in consequence of distention of the stomach is, however, greatly exaggerated, for, except in very unusual cases, the stomach when distended must enlarge toward its free border at the expense of the abdominal cavity rather than of the thoracic. The anatomy of the diaphragm is described on page 320, but its ever-changing position *at the sides* renders the study of its relations to the adjacent viscera of the thorax and abdomen of peculiar value and interest. After death the diaphragm is usually found arching upward to the fullest extent, owing to the collapsed state of the lungs from expiration; but during life its lateral contractions produce changes which are more apparent than real, for there are alterations in the relative positions of the ribs and sternum above and below, which are coincident and exert a modifying influence on whatever effect it may have upon the neighboring viscera. It should be remembered that the ribs are raised in inspiration and lowered in expiration, and that their relations are thus materially altered. To be of assistance in arriving at any degree of accuracy in observation, these alterations are further to be considered from the standpoint of the individual peculiarities of conformation of the chest; and only by those who are most cognizant of what may be termed the normal changes are the difficulties in the way of mapping out the position of the viscera upon the living body properly appreciated.

The shape of the thorax varies considerably in different individuals. The ribs vary in breadth, as do also the sternum and the intervening cartilages (Plates 27, 28, 29).

The uncertainty attending the many descriptions of the position of the heart within the thorax is mainly due to a want of proper consideration of the relative bearing of this important organ to the general conformation and development of the bony cage which contains it. It should be understood and remembered at the outset of every physical examination that the precise location of the various parts must be settled with exactness upon each individual, and that any standard of measurement can be applied only with latitude. It is easy enough to point out where things ought to be beneath the skin, but to say that they actually are at any one spot, without auscultation and percussion, is not compatible with extensive observation upon the living or the dead. An allowance should always be made in fixing upon any diagnostic point, but it may be considerably diminished if sufficient attention is paid to the peculiarities of individual conformation.

It has been asserted (page 245) that the ridge between the manubrium and gladiolus of the sternum is the most reliable landmark in the front of the chest. It indicates the position of the sternal attachment of the cartilage of the second rib, and therefore by counting downward on either side the numerical order of the several true ribs may be ascertained. As already stated, the base of the heart may be considered to be anatomically fixed at the junction of the third costal cartilage with the right border of the sternum. This is fortunate for diagnostic purposes, because it assists in determining the localization of the valves of the heart. The apex of the heart in a well-formed adult may be felt beating at each contraction between the cartilages of the fifth and sixth ribs, to the left of the sternum, and about nine centimetres, or three and a half inches, from its middle.

The thorax should give a clear note on percussion, except over the position of the heart, where dulness is elicited. Only a small triangular part of the heart is uncovered by the lungs and pleuræ during full inspiration (Plates 27, 29, and 30), in consequence of the deflection of the left lung from the middle line. This is known as the *area of the greatest cardiac dulness.* The limitations of this area may be approximately indicated by drawing a line from the middle of the sternum opposite the fourth left costal cartilage to the point of junction of the left fifth rib and its cartilage, and from this point horizontally back to the mid-sternal line (Plate 27).

The following survey of the anterior view of the chest is based upon many careful observations upon the living, and it is believed to be verified by the dissections of this region, as represented in Plates 29, 30, 31, 32, 33, 34, and 35. The references throughout the text, as to the position and bearing of the lungs, the heart, and the great vessels, are also the result of personal study.

In the adult, standing erect, with the shoulders squared and the arms at the sides, if the breath is held *upon expiration,* the position of the valves of the heart may be ascertained, after determining upon the relations of the base and apex of the heart as above described (Plate 27). The *right auriculo-ventricular* or *tricuspid valve* is situated behind the middle of the sternum, opposite the interspace between the right fourth and fifth ribs. The *left auriculo-ventricular* or *mitral valve* is situated just above the cartilage of the left fourth rib, about two and a half centimetres, or an inch, from the border of the sternum. The *aortic semilunar valves* are behind the sternum, between the junction of the cartilage of the left fourth rib and the mid-sternal line. The *semilunar valves of the pulmonary artery* are just behind the junction of the cartilage of the left third rib with the border of the sternum. If the breath is held *upon inspiration,* the interposition of the lungs renders the heart-sounds obscure and uncertain. Fortunately, the structure of the sternum is such that in a measure it serves as a sounding-board, and does not interfere with the transmission of the sounds through a stethoscope.

The difficulty of fixing definitely the points where the sounds of the cardiac valves can be detected by the ear applied to the chest is greatly increased in examining young children, in whom the position of the heart is relatively higher and consequently the sounds of its valves are confused with those of the respiratory organs. In infancy and throughout childhood the heart also is proportionately of greater breadth in comparison with the chest (Plate 42), and the apex-beat will therefore generally be found at a point higher and more external than it is in the adult. The so-called *nipple-line* is not to be relied upon for accurate reference, as the position of the nipple, although usually occupying the fourth intercostal space upon both sides, is subject to variation, as stated in the description of the breast (page 250).

With regard to the physical examination of the chest for the recognition of the condition of the lungs there are several points regarding which the anatomy of the region will offer elucidation. When the hands are held in each other at the back, with the body in the upright position, percussion over the anterior wall of the chest will reveal a clear note wherever the lung-tissue is healthy. By this means an experienced ear and a light touch may enable the physician to map out the area of the lungs in inspiration (Plate 27) and thus ascertain the degree of their expansion. Over the apices of the lungs at the root of the neck there is a slight resonance, but it is much more clear below the clavicles, where the amount of lung tissue is greater. Generally in this locality there is upon the *right* side normally a comparative degree of dulness, owing to the interposition of the innominate artery and innominate vein. Both sides of the chest should always be percussed symmetrically downward, the area of the heart's dulness being allowed for upon the left side. By this means it will be found that in the *middle* over the sternum during inspiration the resonance is clearest along the upper part of the gladiolus, above the attachment of the cartilages of the fourth ribs. Upon the *right* side the resonance diminishes below the level of the *fifth* rib, as the lung thins out over the liver, until the upper border of the seventh rib is reached, where the absolute dulness of the liver commences. Upon the left side below the sixth rib percussion will gradually elicit the tympanitic note of the stomach.

The posterior lower level lines of the lungs are indicated in the topographical survey of the back, which will be found in Vol. II.

The space included between the reflections of the two pleuræ posteriorly, extending from the roots of the lungs and the pericardium to the sides of the bodies of the dorsal vertebræ, is called the *posterior mediastinum* (page 263). It contains the descending thoracic aorta and its intercostal branches, the œsophagus, the pneumogastric nerves, the thoracic duct, the venæ azygos major and minor, the splanchnic nerves, and some lymphatic glands (Plates 36, 37, 38, and 41, Fig. 2).

The *descending thoracic aorta* commences at the termination of the arch, about the lower border of the body of the fourth dorsal vertebra on the left side, and extends to the twelfth dorsal vertebra. It is closely connected to the spine by a strong investment of the endothoracic fascia, and its course is not straight, as it follows the natural curvature of the spine in this region, and gradually approaches the middle line, where it passes through its proper opening in the diaphragm to become the abdominal aorta. The thoracic aorta is separated from the pericardium by the œsophagus and the pneumogastric nerves (Plates 37 and 38). The root of the left lung is in front of its upper portion (Plates 39 and 40), which also indents the lung in this relation. As it descends, this portion of the aorta diminishes slightly in calibre (from twenty-three to twenty-one millimetres, or from eleven-twelfths to five-sixths of an inch, in diameter) and gives off at intervals numerous branches. From the anterior surface arise the upper and lower right and left *bronchial arteries,* which accompany the respective bronchi into the lungs, several *pericardiac arteries,* and four or five *œsophageal arteries,* which are distributed to the walls of the pericardium and œsophagus and also to the posterior mediastinal lymphatic glands. From the posterior surface upon each side there are usually *nine* intercostal arteries given off. There are eleven pairs of intercostal arteries, but the upper two are derived from the superior intercostal branch of the subclavian artery (page 229). The right aortic intercostal arteries are longer than the left, owing to the position of the aorta, being for the most part on the left side of the spine, and the upper ones upon each side ascend obliquely to pass along the *intercostal spaces,* while the lower ones pass transversely.

Upon reaching the intercostal spaces, between the side of the vertebra and the superior costo-transverse ligament, each artery divides into an anterior and a posterior branch. The *anterior branch* is the largest, and at first runs along the *middle* of the intercostal space upon the external intercostal muscle, and, in consequence of the internal intercostal muscle being deficient here, is separated from the thoracic cavity only by the endothoracic fascia and costal reflection of the pleura. At the angle of the rib the vessel passes between the two layers of intercostal muscles and becomes lodged in the sub-costal groove of the lower border of the rib above, with its companion vein above and nerve below (Plate 37). Before doing so it sends off a tiny branch called the *collateral intercostal artery,* which runs along the upper border of the rib below. This branch is sometimes large enough to cause troublesome bleeding, and in entering a trocar through any one of the spaces it is better to select the middle of the space, instead of just above the border of the lower rib as generally recommended. The anterior branches of the intercostal arteries anastomose with one another and with the branches from the internal mammary

PLATE 44.

Figure 1.

Dissection of the anterior thoracic region, showing the superficial fascia and mammary gland on the left side, and the great pectoral muscle on the right. The arms are drawn upward and outward to bring the axillary borders into prominence and expose their relations to the vessels and lymphatic glands; of importance in operations upon the breast. From a female aged twenty-four years.

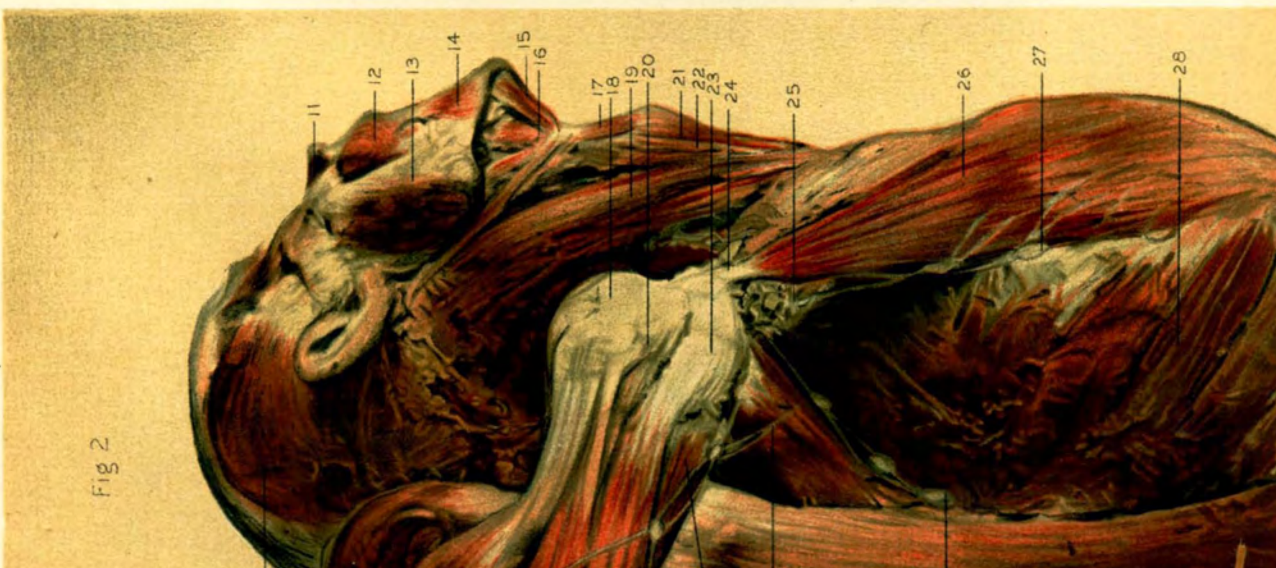
1. The converging fibres of the right pectoralis major muscle, passing to their insertion on the humerus.
2. The anterior cutaneous branch of the first intercostal nerve, and the first perforating branch of the internal mammary artery.
3. The sub-scapular artery, veins, and nerves.
4. The anterior cutaneous branch of the second intercostal nerve, and the second, or principal, perforating branch of the internal mammary artery.
5. The long thoracic nerve.
6. The anterior cutaneous branch of the third intercostal nerve, and the third perforating branch of the internal mammary artery.
7. The long thoracic artery, coursing along the axillary border of the pectoralis major muscle when in this position.
8. The anterior cutaneous branch of the fourth intercostal nerve, and the fourth perforating branch of the internal mammary artery.
9. The middle clavicular nerves.
10. The internal clavicular nerve.
11. The fascia over the great pectoral muscle.
12. The sternal nerves.
13. The superficial axillary veins.
14. The axillary glands.
15. The superior division of the second, or principal, perforating branch of the internal mammary artery.
16. The inferior division of the second perforating branch of the internal mammary artery.
17. The superficial pectoral fascia, surrounding the mammary gland.
18. The left nipple, with its areola.
19. The lower portion of the mammary gland, carefully dissected to show the lactiferous lobes and ducts.
20. The superficial cutaneous veins.

Figure 2.

Dissection of the muscles of the shoulder and axilla on the right side. The lymphatic glands and vessels are superposed upon the photograph, from notes of many observations, to show their proper relations.

1. The temporal muscle.
2. The deltoid muscle, reflected.
3. The pectoralis major muscle, reflected.
4. The triceps muscle.
5. The biceps muscle.
6. The lymphatic chain along the inner border of the coracoid head of the biceps muscle.
7. The coraco-brachialis muscle.
8. The sub-scapularis muscle.
9. The latissimus dorsi muscle.
10. The lymphatic chain along the axillary border of the latissimus dorsi muscle.
11. The compressor naris muscle.
12. The buccinator muscle.
13. The masseter muscle.
14. The depressor anguli oris muscle.
15. The anterior portion of the digastric muscle.
16. The mylo-hyoid muscle.
17. The thyro-hyoid muscle.
18. The head of the humerus, covered with the capsular ligament.
19. The sterno-mastoid muscle.
20. The glenoid head of the biceps muscle.
21. The sterno-thyroid muscle.
22. The sterno-hyoid muscle.
23. The coracoid head of the biceps muscle.
24. The coracoid attachment of the pectoralis minor muscle.
25. The axillary glands in the apex of the axilla.
26. The pectoralis minor muscle.
27. The lymphatic chain along the axillary border of the pectoralis minor muscle.
28. The serratus magnus muscle.

Fig 1



Dissected, Photographed and Colored from Nature by George Mc. Clellan, M.D.

Armstrong & Co. Lith. Boston.

artery in front (page 257). They distribute blood to the contiguous ribs and muscles, and also by perforating branches to the pectoral muscles, mammary gland, and serratus magnus muscle. The anterior intercostal vessels and nerves pass, as they enter between the intercostal muscles, beneath the chain of sympathetic nerve ganglia (Plates 36 and 37). The *posterior* intercostal arteries pass backward with the dorsal nerves between the transverse processes of the contiguous vertebræ, and divide opposite the intervertebral foramina into the spinal and dorsal branches. The *spinal arteries* enter the spinal canal and immediately subdivide and establish communications with the vessels above and below, so that there are arterial plexuses formed in front and at the back of the cord, called the *anterior* and *posterior neural rete mirabile.* A branch of each spinal artery also pierces the dura mater of the spinal cord, and with similar branches anastomoses upon the anterior and posterior surfaces of the cord itself. The *dorsal arteries* divide into internal and external muscular branches, which supply the various layers of dorsal muscles.

The œsophagus is the continuation of the pharynx, and begins in the neck on a level with the sixth cervical vertebra and the lower border of the cricoid cartilage (Plate 12). It is the narrowest portion of the digestive canal, and leads directly into the stomach, passing in front of the spine to the transverse portion of the arch of the aorta, thence through the posterior mediastinum in front of the descending thoracic aorta (Plate 37) to its proper opening in the diaphragm opposite the ninth dorsal vertebra. It is about twenty-five centimetres, or nine or ten inches, in length. It is most constricted in relation to the fourth dorsal vertebra and at the diaphragm. Its course is somewhat peculiar, being not exactly straight, and, besides conforming to the curvatures of the spine in the different regions through which it passes, it deviates from the middle line in certain localities. At the root of the neck it bulges to the left of the trachea (Plate 36), which, with the lobe of the thyroid body and the left recurrent laryngeal nerve, is situated in front of it. It is separated from the longus colli muscles by the prevertebral expansion of the deep cervical fascia. The left inferior thyroid and common carotid arteries, and the thoracic duct, are close to the left side of it. Within the thorax the œsophagus passes through the superior mediastinum, extending over a little to the right of the middle line, lying in front of the bodies of the upper dorsal vertebræ. In the posterior mediastinum it is separated from the vertebræ by the thoracic duct, the vena azygos major, and the right upper intercostal arteries. Here it passes forward and to the *left*, and is surrounded below the roots of the lungs by the œsophageal plexus of nerves, which are derived from the right pneumogastric nerve posteriorly and from the left pneumogastric nerve anteriorly. It is in relation with both pleuræ, but more especially the right, and has in front of it the trachea, the left bronchus, the arch of the aorta, and the posterior surface of the pericardium in relation to the left auricle (Plates 38 and 39). The œsophagus terminates at the cardiac orifice of the stomach, about two centimetres, or three-fourths of an inch, to the *left* of the middle line, passing through the diaphragm, and entering the cavity of the abdomen behind the left lateral ligament of the liver and the adjoining peritoneal layers of the lesser omentum.

Upon section the œsophagus appears like a cord with a stellate lumen (Plate 41, Fig. 2, No. 12). It will be observed from the above that the direction of the œsophagus presents two *lateral* curves, one at the root of the neck and the other at the diaphragm, which should not be overlooked in the introduction of a probang or of the stomach-pump. The diameter of the canal varies, being normally at the above-mentioned points of constriction thirteen millimetres, or about half an inch, and in the rest of the passage from seventeen to twenty-one millimetres, or a little over three-quarters of an inch. These measurements are considerably increased by forcible distention: the narrowest portions, however, rarely exceed twenty-two millimetres, or seven-eighths of an inch, in diameter, while the rest of the gullet will stretch to thirty-six millimetres, or one and a half inches. It follows, therefore, that foreign bodies when swallowed are most apt to be arrested at either the upper or the lower portion of the œsophagus.

The operation of *œsophagotomy* for the removal of an impacted foreign body is performed with the patient's neck turned upon the right side over a pillow, so as to render the *left* side prominent where the œsophagus extends to the left of the middle line. The foreign body can usually be felt, and thus serves as a guide. The incision should be free and made parallel to the anterior border of the sterno-mastoid muscle, and the carotid sheath carefully exposed. The latter, together with the trachea, should be drawn forward and the sterno-mastoid muscle outward, every precaution being exercised not to injure the thyroid body, the thyroid vessels, or the recurrent laryngeal nerve, and especially to avoid tearing the surrounding loose cellular tissue, which is very prone to diffuse inflammation.

The distensibility of the œsophagus is due not only to the laxity of its attachments, but also to the character of its coats. These consist of an *external* or *muscular coat,* composed of outer longitudinal and inner circular fibres, which are mostly well developed and pronounced in the upper portion; a *middle* or *areolar coat,* consisting of elastic tissue in which are embedded masses of adenoid tissue and rows of little racemose œsophageal glands (larger below than above), and an *internal* or *mucous coat,* which is continuous with the mucous lining of the pharynx above and with the stomach below, and which when the œsophagus is empty is folded into vertical rugæ. The mucous membrane is quite thick, and is lined with scaly epithelium. The *arteries* to the œsophagus are derived from various sources. In the neck it receives branches from the inferior thyroid artery, within the thorax branches from the descending thoracic aorta, and below the diaphragm a few twigs from the gastric artery. Its veins empty their blood into the gastric, the vena azygos major, and the inferior thyroid veins in their respective localities. The *nerves* are supplied from the œsophageal plexus formed by the pneumogastrics and some filaments from the first dorsal ganglion of the sympathetic nerve.

The *pneumogastric nerves* within the thorax hold different relations upon the two sides. The *right pneumogastric* enters from the neck, between the subclavian artery and subclavian vein, and descends by the side of the trachea to the root of the lung (Plate 39). After giving off the recurrent branches and others which communicate with similar branches from the left pneumogastric nerve and form the posterior pulmonary and œsophageal plexuses, it continues as a single cord along the posterior wall of the œsophagus to the stomach. The *left pneumogastric nerve*, after entering the thorax from the neck between the left subclavian and carotid arteries and behind the left innominate vein, passes over the arch of the aorta and behind the root of the left lung to the anterior surface of the œsophagus. In its course it gives off branches which combine with those from the right pneumogastric nerve, as already stated, in the formation of the pulmonary and œsophageal plexuses, and continues as a single cord along the anterior wall of the œsophagus to the stomach. The recurrent laryngeal nerves are given off from the pneumogastric nerves within the limits of the superior mediastinum, and have already been particularly described (page 185).

The thoracic duct is the upward continuation of the receptaculum chyli, which receives the converging lacteal vessels from the intestines and the lymphatic vessels from the lower portion of the body, which are described with the region of the abdomen in Vol. II. The duct enters the posterior mediastinum by the aortic opening in the diaphragm, to the right side of the aorta (Plate 37, No. 8, and Plate 38, No. 2), and ascends in a sinuous course in close relation to the right pleural boundary of this space as far as the body of the third dorsal vertebra. Here it passes across to the left side behind the arch of the aorta and the œsophagus, and curves upward to the left side of the latter, between it and the left pleura, to enter the superior mediastinum. Very often the thoracic duct in its upper portion divides into branches, and it usually presents a dilatation where it crosses over the spine. It receives the pleural, intercostal, and left pulmonic lymphatic vessels. When dilated it appears irregular and nodulous, owing to the many pairs of valves with which it is provided. The valves are most numerous in the upper portion, where it ascends between the œsophagus and the left subclavian artery into the neck as high as the seventh cervical vertebra. It then curves downward *over* the subclavian artery, near the anterior border of the scalenus anticus muscle, and empties into the back part of the confluence of the *left* common jugular and subclavian veins (Plate 20, No. 69). At the orifice of the duct there are two well-marked valves, which guard against any regurgitation of the blood from the veins into its canal.

The *vena azygos major* is the great connecting link between the superior and inferior venæ cavæ, making up for their deficiency in the situation of the heart. It commences by tributaries from the right lumbar and renal veins, and often from the inferior vena cava itself, and, passing through the diaphragm at the aortic opening, ascends upon the right side of the spine over the right intercostal arteries to the third dorsal vertebra, whence it arches forward to empty into the superior vena cava as it becomes covered by the pericardium (Plate 37, No. 30). It receives the lower nine or ten right intercostal veins, the spinal veins, and the posterior mediastinal, œsophageal, and right bronchial veins. About the sixth dorsal vertebra the vena azygos major is usually joined by the *vena azygos minor* (Plate 38, No. 13), which ascends up the left side of the spine (Plate 36, No. 84). The latter vein commences in the abdomen by tributaries from the left lumbar veins and the left renal vein, and ascends to the left of the aorta through the left crus of the diaphragm. It receives the lower six or seven of the intercostal veins, besides some of the mediastinal and œsophageal veins. The left upper intercostal veins terminate in a trunk called the *superior vena azygos minor*, which empties into the vena azygos major generally, but sometimes into the inferior vena azygos minor. All the azygos veins are provided with valves, which are not very perfect, however.

The *splanchnic nerves* are the sympathetic nerve cords which are made up of branches from the lower thoracic ganglia, and are distributed to the abdominal plexuses under the names of the greater and lesser splanchnic nerves (Plate 36, Nos. 80 and 83, and Plate 37, Nos. 13 and 15). The sympathetic ganglia in the thoracic region vary in number upon each side from ten to twelve, in consequence of several of them being often united. The *first* is the largest, and they are mostly situated over the heads of the ribs. They are small, grayish-pink, irregular bodies connected by broad, thin, grayish branches, and each ganglion is also connected by a couple of branches, one white and one gray, with the neighboring intercostal nerve. It is thought that these connecting links with the spinal nerves consist of fibres which leave the ganglia at their inner branches and endow them with vaso-motor and viscero-inhibitory functions.

The nerves from the *four upper* ganglia are quite small, and pass inward to join the cardiac and posterior pulmonary plexuses. The nerves from the *six lower* ganglia constitute the greater, the lesser, and the smaller splanchnic nerves. The *great splanchnic nerve* is composed of the most numerous filaments from the fifth, sixth, seventh, eighth, ninth, and tenth ganglia, which combine into a single trunk, and, passing through the crus of the diaphragm on the corresponding side, join the solar, renal, and supra-renal plexuses. The *lesser splanchnic nerve* arises by branches from the tenth and eleventh ganglia, and passes generally to the cœliac plexus; and the *smallest splanchnic nerve* arises as a collateral branch from the twelfth ganglion, and terminates in the renal plexus. The chains of the sympathetic ganglia and their nerve-cords are covered by the reflection of the costal pleura upon each side, which holds them in place, and which must be removed before they can be examined and followed through the diaphragm. The association of the filaments of the splanchnic nerves with the solar plexus probably accounts for many of the obscure symptoms complained of in dyspepsia, which by reflex action manifest themselves in pain in the area of distribution of the cutaneous nerves of the upper part of the back.

THE DIAPHRAGM.

The diaphragm is the thin, movable, arching partition which separates the cavity of the thorax from the cavity of the abdomen. Its construction is very peculiar, as it consists of muscular and tendinous portions which arise by numerous digitations and, arching upward and inward, converge to be inserted into a common *central tendon*. To the upper surface of the central tendon are attached the fibrous pericardium and the dense lateral bands which are prolonged from the deep cervical fascia, already described (page 259). These serve to maintain the arch of the diaphragm and to keep the central tendon in position while the muscular portions are in constant motion during respiration (page 273). When looked at from *below*, the whole diaphragm resembles somewhat a large palm-leaf, while the central tendon appears almost a counterpart in form: hence the differ-